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Wings of the Intruder 4

The producers of *Flight of the Intruder* — a Vietnam War film about Navy pilots who embark on an unauthorized bombing mission over Hanoi — received plenty of support from the U.S. Navy. But for scenes too difficult or too dangerous to achieve with real aircraft, visual effects supervisor Mark Vargo was enlisted to orchestrate a vast comingling of radio control and wire-flown aircraft, expansive miniature settings, pyrotechnic explosions, motion control photography, cel animation and computer generated imagery. Nearly a dozen effects companies were employed in the effort. *Article by Bill Norton.*

Clash of the Robotitans 24

For the second chapter in his *RoboCop* saga, producer Jon Davison managed to assemble almost all of his original effects artists. Rob Bottin produced a new robosuit and an animatronic cyborg torso. Phil Tippett directed a massive stop-motion effort. Craig Davies designed and constructed a formidable mechanized monster. Peter Kuran supplied robovision effects and Rocco Gioffre provided futuristic matte paintings. Added to the effects roster for *RoboCop 2* was the computer graphics firm of deGraf/Wahrman and an on-set computer graphics team headed by Paul Sammon. *Article by Jody Duncan.*

Maximum Impact 46

Set within and above an international airport during a major blizzard, *Die Hard 2* was a more than substantial challenge for both special effects coordinator Al Di Sarro and visual effects supervisor Michael McAllister of Industrial Light and Magic. While Di Sarro wrestled with the problem of supplying tons of biodegradable simulated snow — the real thing was proving elusive, even in normally snowbound locations — a miniatures unit from ILM was flying and crashing gigantic airplane models in the windswept Mojave Desert. *Article by Mark Cotta Vaz.*

FRONT COVER — Detroit's answer to street crime returns to duty in *RoboCop 2*. The cyborg police officer makes an unhelmeted appearance. — BACK COVER.

Wings of the Intruder

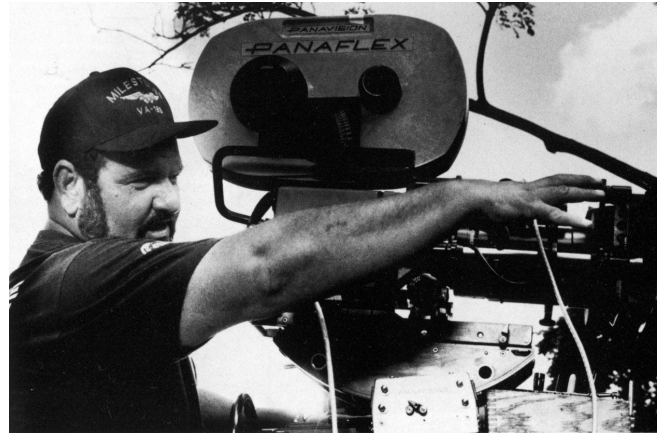
article by

Bill Norton

The engine exhausts of the warplane are two bright meteors above the dark Asian jungle. Inside the cockpit, the pilot and bombardier are intent on guiding their machine to its target, aided by complex instruments and displays. Suddenly, the A-6 Intruder is rocked by terrific concussions as flak explodes with flashbulb brilliance close to the aircraft. Tracers lace the night sky. The hot sweat that bathes the men turns suddenly cold as a tone sounds in their earphones and a red warning light flashes. With unerring precision, a missile rises in the distance and guides to its prey on an angry tail of flame and smoke. At the last moment, the pilot whips the plane around in a crushing turn as he presses the button that dumps a cloud of metal chaff. The missile's electronic brain is bewildered by the countermeasure and slices by the Intruder without detonating. Moments later, a dozen dark shapes drop away from the plane and, with ear-splitting detonations, the bombs deliver their destruction.

This account of an air attack during the Vietnam War was typical of the battle scenes found abundant in the script for *Flight of the Intruder*, a John Milius film adapted from a late Reagan-era techno-thriller written by then first-time author and ex-naval aviator Stephen Coonts. Set in 1972, *Flight of the Intruder* is the story of men struggling to keep faith with each other while also remaining true to their duty, even to the contradiction of orders. A-6 Intruder pilot Jake Grafton (Brad Johnson) struggles with this moral dilemma after bringing his dead bombardier/navigator Morgan McPherson home after another in a series of seemingly pointless bombing missions over inconsequential North Vietnamese targets. Grafton is subsequently teamed up with Virgil Cole (Willem Dafoe), who is ripe for the

image



On location in Hawaii — doubling for Southeast Asia — director John Milius rehearses the action in a scene from *Flight of the Intruder*. Based on the bestselling novel by Stephen Coonts, the high-energy war film follows the hazardous exploits of a pair of Navy flyers who — disgruntled by the meaningless targets they are regularly assigned — determine to launch an unauthorized air strike against the North Vietnamese capital of Hanoi.



The film company prepares for a shot on the flight deck of the USS Independence. Although cooperation from the Navy was extensive, it could not be all-encompassing. To accomplish scenes of aerial combat and urban bombing, visual effects supervisor Mark Vargo was engaged to assemble and oversee a small army of effects artisans and facilities.

suggestion that they go after a target of real strategic value in an effort to make their friends' deaths mean something. The result is an unauthorized low-level attack on the heart of Hanoi in the face of murderous flak and surface-to-air missile defenses.

As with similar projects, the production began by securing permission from the Navy to film actual military aircraft and shoot on board an operational aircraft carrier. Beyond that, it was acknowledged that extensive model and optical effects would be needed to provide much of the fast-paced and intricate footage needed to depict modern aerial warfare. Hired as effects supervisor was Mark Vargo, who unhesitatingly decided to utilize a wide assortment of effects techniques to create the varied combat scenes. Vargo had already spent many years in effects, including five with Industrial Light and Magic and four as optical supervisor at Boss Film Corporation. He had also spent some time at Robert Abel and Associates as postproduction supervisor. Flight of the Intruder would provide a singular challenge. "I had never worked on a war movie that had so much potential — visually, anyway. It was a great challenge to make it as real as possible with the amount of money we had — about \$3.5 million — and the amount of prep time we were given. John Milius also sets very high standards." Apart from his visual effects responsibilities, Vargo was also handed a great deal of second unit directing and other photographic chores. For the most part, the effects supervisor was allowed free rein in assembling his team. Principal among those selected were production coordinator Laura Lang, who had filled a like role at Dream Quest on The Blob and Total Recall, and effects art director David Goldberg, who most recently had been miniature construction supervisor for The Abyss. Vargo was also permitted to hire his own effects editor and brought in Steve Moore who would eventually edit much of the complex air battle that climaxes the film.

Vargo would ultimately have a dozen companies working on the visual effects. The decision to go this route rather than using a single large effects house was due to the many varied techniques he chose to employ, cost and schedule considerations, and because he wanted the majority of the work to be done close enough to the Paramount home lot to permit quick consultation. "I had sole authority on who I wanted to use," Vargo said. "I had to go through the proper presentations to state my case, but I was not overruled on any of my choices. Part of the calculus in figuring out the effects houses you want to work with is a raw sense of how much work they can do independent of daily supervision. That really helps the process in terms of making the schedule. I know as well as anyone how much time it takes to do things. So if I felt like we were running behind on something, I had a leg up on the decision to correct it. The communication that I had with the show was absolutely essential to getting it done on time. I would have preferred to have the director more involved in the effects process, but he was very difficult to schedule time with. So we just had to rely on our professional instincts and tastes in preparing this stuff for the movie."

Most of the effects work would have to await the end of the very demanding principal photography phase. Veteran production designer Jack Collis had been brought on in June 1989 and immediately began preparing for an October start date. The crash of A-6 squadron commander Frank Camparelli (Danny Glover) and the rescue effort that followed were photographed early in the schedule on location in Hawaii. The site chosen was at the base of Mount Waialeale on Kauai, advertised as the wettest place on earth with about five hundred

inches of rainfall a year. Collis had the enormous task of transforming the area into a facsimile of North Vietnam. "We had to build a road up to the site. That was a long haul and took tons and tons of rock because it rained so much that everything would sink out of sight. We acquired a salvaged A-6, put it on a barge to Kauai and hauled it up in sections. Then we beat the bejezzus out of the thing and dug it into the earth like it had come through the rice paddies. Joe Lombardi — one of the top special effects men in the industry — set up all the napalm runs and the gun effects." Other location work included a week of interior photography dockside on the aircraft carrier USS Independence. Carrier flight operations were filmed later during an eight-day cruise off the California coast.

Badly shaken by his friend's death, Grafton is temporarily pulled from combat to ferry one of two A-6s to the Philippines. The flight becomes a wild aerial chase at frighteningly low altitudes when Jake and another pilot wager five dollars on a wild game of follow-the-leader. Practical photography of real aircraft predominated the sequence — as it had with the Camparelli crash. Clay Lacy's venerable Learjet camera ship was used to obtain air-to-air POVs and low-level aerial night footage of lighted buildings and terrain flashing by with an A-6 occasionally in the shot. The latter shots — filmed near Savannah, Georgia — were used largely as rear projection plates for shooting actors in a cockpit mockup on the soundstage. Additional cameras were mounted on the A-6. All of the aerial photography was recorded in four-perf format for subsequent enlargement to eight-perf Vistavision. "Straight Vistavision would have been better," Vargo admitted, "but there are no Learjets configured to hold Vistavision cameras. Fortunately, the film these days is so good that you can get away with blowing it up."

Jack Collis and crew were responsible for the Intruder mockups needed on stage so that the actors could be filmed inside the cockpit with in-flight footage visible through the canopy. "We had to put the full mockup on big hydraulic rams so that it could be tilted," Collis related. "We wanted to turn the thing three hundred sixty degrees, and some of the action called for very high gimbal situations because of the size of the plane. We could not rework the wings, so we foreshortened the body of the plane to get it to fit in front of the process screen. About six feet was taken out of the plane and we did a forced perspective on it so that when the plane turned into the camera it was not apparent that it had been foreshortened. We took plastic molds off salvaged parts to build up our own plane, and eliminated a lot of weight up there in the process. The gimbal foundation was based on one from *The Hunt for Red October*. We built everything else new because our unit needed to work much faster and had to be much higher. To mount the airplane, we had to locate an attachment point that was strong enough, but would still give us an axis of rotation for realistic movement. It got to be a very complex bit of engineering which was all done by our construction coordinator, Dennis DeWaay, who also built the two gimbals for *Red October*."

Separate cockpit mockups were assembled for other filming chores. "We shot the crew in the small mockup against a bluescreen," Vargo said. "We had to go with bluescreen rather than front or rear projection because we didn't have the optical or computer graphics elements yet, but we had to finish with the principal actors. We also shot some bluescreen pilot POVs through the canopy as cutting pieces for the editors and as insurance in case we had some problems later."

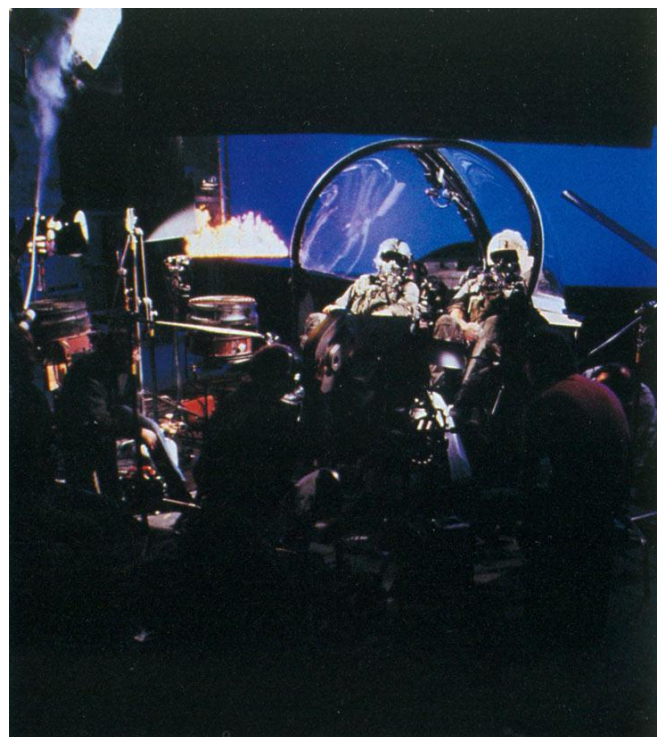
As the production unfolded, Vargo and company found themselves committed to some of the most extensive use of radio controlled flying models yet seen in a feature film. This was partially dictated by the frustrating coordination, limitations and expense of working with actual military aircraft. "There were some shots that we couldn't get with any other technique but radio control," Vargo confessed. "Also we wanted to get as much of the flying shots on original negative as we could to avoid postproduction. It saved us money. I feel that the art of special effects now — visual effects particularly — is becoming more and more like general production as far as using cameramen, moving cameras, thinking in terms of practical stuff and running it real-time."

The source for these radio control effects was Richard Booth and his Eaglery company. "Shooting RC models in films has always meant using a static camera and having the model do a flyby," Booth related. "When models are shot that way, they get big very fast and they get small very fast. So you end up with very small amounts of usable footage." For a couple of years, Booth had been toying with the idea that a simple solution might be to film from a moving camera car with the radio control 'pilot' riding along and flying the plane as directed. A low-budget film project — ultimately unrealized — provided funds for a successful test that would eventually win favor with John Milius and the Intruder effects team. "You can get a plane-to-plane look and a full ten minutes of uncut aerial aerobatics with two planes. The models are constantly the same size in frame — just like real plane-to-plane shots — and speed is not a problem because in the air you have no perspective of speed anyway. It also works great for explosions. One of the tackiest shots in film-dom is the slam-cut to a model hanging on a wire and it blows up. But it blows up equally in all directions. When you blow up a flying RC plane, the heavy parts will spin forward with the momentum and the light parts will blow back with the wind."

Given the go-ahead, Booth immediately put together a team of experienced radio control modelers and established himself in a shop at the Van Nuys airport where work began on the A-6 models. "Arbitrarily, we decided to build a ten-foot-long airplane. We built a 'clean' gear-up version



Dodging surface-to-air missiles and anti-aircraft fire, aircrew members Virgil Cole (Willem Dafoe) and Jake Grafton (Brad Johnson) guide their A-6 Intruder through the heavily defended approach to Hanoi.



and a gear-down 'dirty' version — two of each so there would be backups. They were interchangeable because I didn't want to have primary planes that we would have to wait for if we had a mechanical problem. So we built a lot of redundancy into their systems. The clean airplane weighed around thirty-six pounds and the dirty version was about forty. We used 90cc, two-stroke, two-cycle engines with Byron ducted fans. We got fourteen pounds of static thrust out of those turning at 22,000 rpm, and we were getting about eight to ten minutes flight time. The planes had all-moving horizontal tails — like real A-6s — and the clean airplanes had spoilers on top of the wings for roll control. The dirty versions flew with the usual aileron control because they were shot only from below and we didn't need to see the spoilers on top." The dirty models also included operable wingtip split speedbrakes.

Booth engaged Mark Hambelton and his company DCU to create the A-6 fuselage plug and molds and then provide the fiberglass shells and incidental vacuformed parts. Eaglery modelers then performed the rest of the construction. "It was a horrendous challenge in the beginning to make it light enough," Booth stated. "We had doubts that this airplane was even going to get off the ground. We had Mark making the fuselages thinner and thinner until he had reduced the weight by half. We put in only two bulkheads — one for the wing support and one for the engine mounts — instead of six as you probably would to build a really good model. We didn't think the model could do an aileron roll without coming apart — but it did. Even so, we feared that we had gone too big for the available power, and that was the reason for making a lot of decisions that we probably did not need to make, like not using retractable landing gear. As it turned out, we made it much lighter and weaker than we needed to. The plane flew much better than we ever dreamed it would — and the reason is the basic design was so good. Grumman built that airplane to lift a hell of a lot of iron bombs."

The gear-up models were launched from a dolly and then recovered by belly landing after external stores were jettisoned. Later it was decided to simply land on the dummy centerline fuel tank to reduce abrasion damage to the bottom of the plane. "The launch dolly had a steerable nose wheel with a servo. We steered it down the runway; and when the plane lifted off, it disconnected the contact to the servo." The dolly launch proved to be a heart-stopping event since the plane just barely reached flying speed on it and the spoiler roll control was very poor at such low velocities. A much more successful system employed a pipe array mount in the back of a speeding El Camino with the plane held down by hand until the vehicle had reached the model's flying speed.

"We had fourteen servos per plane," Booth recalled, "but we had only nine-channel radios. If we needed to use all the gags in one take, there would have to be two radios. We could drop bombs by remote control and even had articulated pilots. The dummy crew sat with little silks folded up on their backs. We had a canopy ejection system loaded like a crossbow using a rubber band, and the ejection seats had little tubes in the bottom for model rocket engines. The idea was that the canopy would go, the seats would eject out of the plane, the crew would separate from them

For the interviews, we went to the airport and a full A-6 cockpit in the center of the hangar. The planes were not yet assembled when the motors were a high speed drill bit. The engine was by a piston engine and the reflection of the A-6 cockpit mockup was similarly rigged.

and the silk would trail out flapping. At that point we would have to cut because there was no way to make a tiny chute look real, even with overcranking.” External details needed to alter the craft to an A-6B — configured to carry the large radar-homing Shrike missiles for the SAM suppression mission — could be hastily applied with quick-drying cement. The planes were also rigged to carry Snakeye bombs which have fins that pop out on release to slow and steepen their descent. Once released by radio command, each bomb would drop a few inches until fishing line connected to the plane was fully extended and pulled a pin out of the bomb. This in turn released restraining wires connected to the deployable fins which were then rotated open by the slipstream. Many of the features, such as the articulated pilots and the canopy ejection system, were never used.

The Eaglery team also provided a number of other incidental aircraft. “We built an SH-3 Sea King helicopter. It came from a flying helicopter kit and we just mounted the tail rotor up higher and put the SH-3 fuselage on it.” The Sea King was to be used for a scene in which one of the pilots — ‘Boxman’ — is killed when his damaged Intruder crashes onto the carrier deck. The scene was later cut and the helicopter was never filmed. Instead, Boxman is killed by a missile during Grafton’s first mission with Cole. After firing a Shrike and evading the SAMs, the A-6 is intercepted by a North Vietnamese MiG-17 which fires an air-to-air missile at its prey before being chased off by F-4 Phantoms. “We made three F-4s — because two were needed in the air at once — and two MiG-17s. The F-4s and the MiGs were about ninth scale. I saved the company some money because they both come as kits.” The MiG was built to fire a model rocket simulating an air-to-air missile. Both the MiG and the F-4 models had retractable landing gear, although the tires remained partially visible. These aircraft could stay airborne for only about six minutes before exhausting their fuel supplies.



Radio control models were used extensively to provide flight footage that could not be obtained with real aircraft. Four ten-foot-long A-6 models were constructed and flown under the auspices of Richard Booth and his Eaglery company. Employed also were three smaller-scale F-4 Phantoms and two MiG-17 interceptors.

The production company provided Eaglery a huge semi to carry their planes and equipment, and the unit began the first of several location filming sessions in late February. "It was a concern of ours to match the Southeast Asia sky," said Vargo, "so we thought about going to Georgia or Florida to get that tropical puffy cloud look. We talked about doing the simulated carrier approaches at the Salton Sea because we could shoot across and see nothing but water." Consideration was given to going back to Hawaii, and a shoot over the rice paddies in Sacramento was also discussed. The predominantly nighttime setting and pressures of the schedule and budget were the final arbiters in the location decision. Filming took place primarily at China Lake Naval Air Station and at the El Mirage dry lake bed, both in Southern California.

The Navy base offered an eleven-thousand-foot runway for prolonged high-speed camera truck runs. The remote desert locations also reduced the chance of radio interference which was likely in the electromagnetically 'noisy' Los Angeles basin.

Nearly all of the radio control work was filmed day-for-night on standard four-perf stock. "With a blue sky," Dave Goldberg explained, "we could use red filters and shoot black-and-white film to darken it down. That would then be printed blue and darkened even more. The color shots done day-for-night just had to be printed down." The cameras were overcranked only slightly — thirty-six and forty-four frames per second — for the normal flying. Both static camera and camera car shooting were involved. The camera car was a powerful custom-built truck called the Shotmaker which had positions for two cameras in the rear. During runs on the dry lake bed, the vehicle's path had to be wetted down by a water truck to suppress the dust. Since the A-6s flew at fifty to sixty miles per hour, the truck rides were quite lively. The models had to be operated at full throttle just to stay airborne, so the Shotmaker had to vary its speed for positioning relative to the plane. The fighters flew much faster — between one hundred twenty and one hundred forty miles per hour — and so were shot mostly from a static camera position on a tower. The F-4s were filmed as a formation of two and the MiG-17 was shown closing on an A-6 from behind, where the difference in scales was irrelevant. "We shot it with an extremely long lens which compressed the image," Vargo noted. "So as the MiG drops down into frame behind the A-6, it looked much larger than it actually was."

Precise pyrotechnic effects were supplied by Joe and Paul Lombardi and their Special Effects Unlimited shop in Hollywood. With external smoke canisters, primer cord laid out on the exterior of the plane and internal gas bombs, the Lombardis rigged the A-6s to break up and explode. No prescoring was necessary. Two explosions were required — one to show Boxman's death and another to show Grafton and Cole's A-6B blowing up. Filmed at one hundred twenty



To achieve convincing simulations of air-to-air photography, the low-flying models — moving at speeds up to sixty miles per hour — were controlled from the back of a speeding Shotmaker truck equipped with two cameras to cover the action. Most of the footage — recorded slightly undercranked — was shot on the open expanse of a dry lake bed in the Southern California desert.

frames per second and covered by two static cameras as well as the speeding Shotmaker, the pyro-laden models were detonated by radio while the planes were in flight. Since radio silence had to be maintained for safety reasons once the charges were armed, police whistles and flags were used to signal between the widely separated cameras. Boxman's death was executed well, but a roll during the A-6B run placed it too near the ground when the charges were fired and another plane had to be destroyed before the shot was satisfactorily obtained. Only one flying Intruder remained.

The Lombardis also provided practical flak bursts. A line of eleven mortar assemblies, each containing five tubes, fired small charges that burst with either black or white smoke to convincingly depict the murderous gauntlet the Navy aircrews had to face. A small charge on the tail of the A-6 was fired in the midst of the flak to simulate a hit on the plane. Vargo had hoped to obtain a shot showing water spouts geysering up near the plane for a scene of shells falling around it during a low-level run along the Red River near Hanoi. No convenient water location could be found where such unusual activity was permitted, so the Lombardis set charges in twenty-three tubs of water in a line along which one of the models would fly during filming. Fading daylight, however, nixed the idea until another day when the shot was obtained using a plane on a truck-mounted gimbal rig filmed in motion from the Shotmaker. The Lombardis designed and built the pickup truck gimbal boom arm which could accommodate one of two nonfunctional A-6s built by Eaglery. The waterspout effort was for naught, however, as the scene ended up on the cutting room floor.

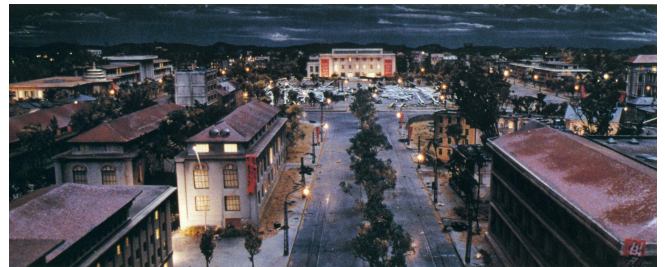
The Lombardi gimbal rig had been designed primarily to provide controlled filming of the A-6 in flames. It had motorized roll and went up and down manually while staying parallel to the ground. The A-6 was attached to the gimbal by means of a pipe through its tail and was shot both moving from a camera truck alongside and static with a ground camera and wind machine to provide the rushing air. One of the models was used to show the wings and fuselage of the plane engulfed in flames. The first shot employed propane gas piped into the model and ignited remotely. After hasty cosmetic work, a second shot was rigged with the wings and center fuselage covered with a sheet of flammable material that could be electrically ignited. This shot required a quick flare up, a sharp roll and a subsequent dive, and needed to be carefully orchestrated. The gimbal rig was also used to obtain further footage of the miniature pilot ejections which was later intercut with radio control footage and actual ejections from a ground mockup filmed at China Lake.

It was apparent to all that the unauthorized raid on Hanoi would provide the effects team with its greatest technical challenges — not the least of which was the fact that the city and its approach would have to be rendered fully in miniature. Early on, it was decided that a test would be needed to determine the optimum scale for the setup. Vargo called Tom Barron and his Image G company — which shoots the miniatures for *Star Trek - The Next Generation* — to assemble a rough cityscape and shoot some overflight footage. "The test was principally designed to give everybody a sense of how fast five hundred miles per hour is and how much terrain would be covered during the low-level run," said Vargo. "The second objective was to determine whether model railroad N-scale would be good enough to pull it off. If we'd gone to HO or some larger scale, the set would have ended up being hundreds and hundreds of feet

long to represent the five miles that we needed to build. At five hundred miles per hour you have to have a lot of model to sell the sequence. So we shot this very small version of an N-scale boulevard in September. It was thirty-three feet long, and it had about a block's worth of buildings on both sides of the street. The test was enlightening from a couple of different standpoints. It allowed us to determine that N-scale would indeed work, and it gave us a background plate that we could attempt to add airplanes to."

The test footage was passed to Introvision — specialists in interactive process photography — to produce a composite with an aircraft over the street. "Introvision had an F-4 model that they used," Vargo continued. "The movement wasn't perfect and the scale of the airplane wasn't absolute, but it was enough in a rudimentary sense to really help our decision making process. The thing that struck me about it was the image instability they had introduced. Intentional shaking of the camera added something that would be very difficult to achieve by a conventional visual effects approach. On the basis of the test results, I selected Introvision and Image G for the Hanoi material."

In the sequence, the Navy pilots would make their assigned run over a power plant and then deviate from their mission plan and follow the Red River to Hanoi for a low-level pass over the city. Jack Collis and his art department formulated the initial designs. "My art director, Al Heschong, specializes in that kind of thing. We discussed what the miniatures would be and then laid everything out. It was important to figure out how fast the plane would be flying, what kind of movement it would have and what scale we would need to employ. When I told the producers how big this miniature was going to be, none of them would believe me. I said, 'Gentleman, you're flying at five hundred miles per hour and you have to have enough model for the whole scene to play.' I also showed them the bridge at Hanoi. The original bridge on the Red River is one and a half miles in length. We drew that out and showed them what the length would be, even in this tiny N-scale. It was just massive!"



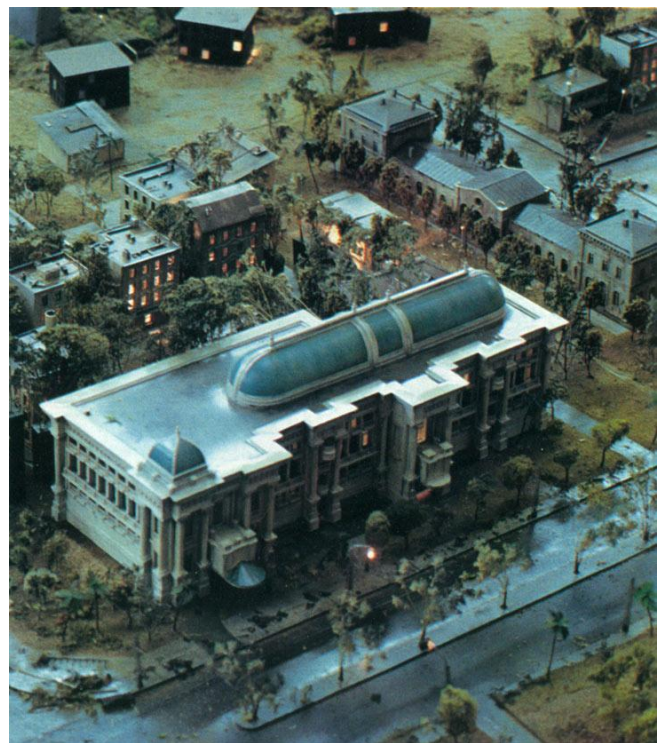
To produce background plates for the nighttime bombing of Hanoi, a miniature representation of the city was built in a North Hollywood warehouse by Don Pennington and company. Constructed at model railroad 'N-scale' — the smallest scale considered allowable and one that afforded a wealth of off-the-shelf materials — the miniature was nonetheless about two hundred ten feet long and covered some thirty-five hundred square feet of tabletop space.

These terrain miniatures were built by Don Pennington and company. Pennington had a long history in movie miniatures, both on staff for effects houses and as an independent, but this was the largest job he had undertaken. The huge Red River and Hanoi miniatures were separate narrow units joined by a smaller dog-leg section to form an extended horseshoe shape. The dogleg was dominated by the expansive railroad bridge that crossed the river and led into Hanoi. A cyclorama depicting a dusky sky with large cumulus clouds backed the outer periphery of the horseshoe. The river was made of masonite covered with linoleum and urethane to catch the nighttime reflections. "The forty-foot dog-leg was all one piece which we could unbolt and move around," Pennington explained. "The Hanoi street portion was about eighty feet and the Red River seventy feet, so we had a miniature about two hundred ten feet long that covered an area of about thirty-five hundred square feet. It's probably the largest N-scale model ever, but we're still a little under half the size of 1941's Hollywood Boulevard miniature."

Pennington began construction in October in an empty North Hollywood warehouse. "The production drew us a footprint of how they wanted downtown Hanoi laid out. We did a week of projecting square footage and deciding how we were going to attack it. We used Air Force reconnaissance photos plus National Geographic and Life magazines. Our aim was to make it pretty accurate, but there was some license taken to jazz it up a little by adding a refinery and putting a railyard across the river. We also added an island and sandbars just to break up the immenseness of the river. A couple of pontoon bridges were thrown in to cover seams. About fifty-five buildings were custom-made to match real buildings in Hanoi. Some of them that were on secondary streets we moved and put onto the main street to dress it and make it look better. In all, we must have had about seven hundred buildings. There wasn't time to scratch-build everything — which is one of the reasons we went to N-scale. A lot of the stuff could be bought off the shelf. We also did about fifty thousand trees — Ans Ellis supervised that part of the job."



Modelmaker Ken Swenson positions tiny surface-to-air missiles in the city center.



Although many of the buildings were generic model railroad kit structures, more than fifty of them — particularly those along the main flight path — were custom-made to match real buildings in Hanoi.

After coordinating with Image G — which would be providing the motion controller and camera — Pennington decided to build on tables so that his modelmakers could get under the miniature for ready access. “We started with seven feet of ‘Hanoi Street’ and built out from there. We built in modular block form using masonite pads. When it came time to put it all together, we just put the pads down on the table.” To save time and expense, only the buildings facing the main boulevard along which the camera traveled were highly detailed, even down to tiny photo-etched brass bicycles parked in front. These were termed ‘A’ buildings. The ‘B’ buildings were less detailed and ‘C’ buildings were simply blank, painted walls with reasonably detailed roofs throughout. Work was concentrated on the two walls visible to the camera. A hospital building was included to tie in with a much larger miniature built by Isidoro Raponi at Paramount. The studio model had two large Red Cross banners that rolled up the facade of the building to reveal articulated antiaircraft gun emplacements that engage the attacking A-6.

Pennington’s construction team — headed by Dave Kelsey and Ray DiCarlo — added some moving elements to enliven the scene. “We had two trolley cars and two trucks going across the street and a train that went about six feet across the bridge. A nine-volt battery was used for interior lights on the train. It was good for two passes and was concealed in one of the cargo cars. We put a little microswitch on the tracks so that as the train went by it would turn the lights off after it was out of view of the camera. That saved us climbing on and off the model a lot to replace the battery. Everything ran on N-gauge track and we used motion movers with servo motors that were scanned into the speed and start/stop times of the camera as it flew by. We used woven cable to work with the mover and pulleys, and we slotted the track so that the cable would go down the track and just pull the model along.”

Since the raid was to take place at night, hundreds of tiny light sources were incorporated into the miniature. “We went from Christmas tree bulbs near the center of the camera pass to fiber optics at the outer edges of the model to support the impression of distance. All of the Christmas tree bulbs — about four hundred of them — were used for building interior lights. Wheatbulbs were used for the light poles on the main street and for the navigation lights on top of the bridge. We also used clear acrylic that we painted black and then scribed into and backlit to show the city spread out in the distance. The city was supposed to be about five scale miles long, so we had different lighting brilliance in a grid pattern to make it look like a real city does at night. We used about eight miles of fiber optics for another twenty-five hundred to three thousand lights.” After the Hanoi miniature was photographed and dismantled, a smaller-scale terrain model which included the power plant for the initial part of the Hanoi raid was constructed. “It was a circular miniature — about thirty-three feet in diameter — representing about three scale miles for high-altitude shots. Dave Goldberg built the power plant.” In all, the Pennington crew of thirty-seven full- and part-time workers expended ten thousand man-hours on the models over a period of eight and a half weeks.

The Image G motion control camera — called the ‘Bulldog’ — ran on seventy-five feet of track positioned between the legs of the U-shaped tabletop model. “The Bulldog is the world’s largest and fastest computerized camera crane,” Tom Barron asserted. “Its removable boom allows it to reach twenty-three feet, and with servo motors it can achieve speeds in excess of one hundred twenty inches per second. Normally we run with servos, but on Flight of the Intruder — where

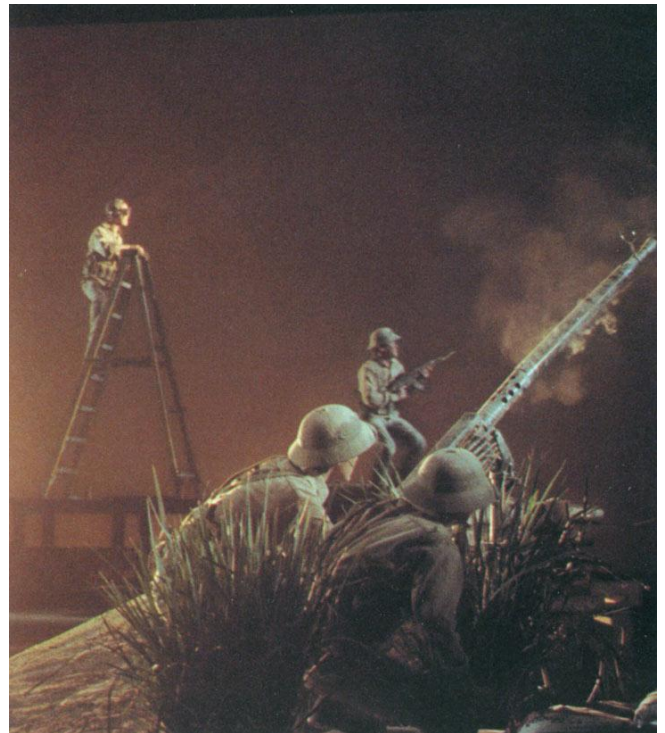
we had long exposures at low light levels — we reequipped with steppers. This significantly reduced the danger imposed by such a large rig working in a confined model set over an extended period of time.” Barron also designed an aerial image video tap to permit rapid visualization of the programmed move in extreme low light levels. An outline displaying what the film format would actually record and a tracking reticle were superimposed on the video screen. “We used time-lapse video so that we could quickly review move passes real-time without having to shoot black-and-white film and wait for it to be processed,” commented motion control cameraman Adrian Hurley. “That way, I was able to get a path of action down and make a move in just a couple of hours.” As configured, the Bulldog could proceed down the track at ten to twelve frames per second.

The necessity for the camera to get within inches of the model without having to flop the footage or suffer the quality loss attendant with snorkel or periscope lenses induced Image G to construct a new, smaller camera with an eight-perf movement and a custom pan-and-tilt head. “Some of the plates were going to be used as process plates on the live-action stage and others were to be Introvision plates,” Dave Goldberg explained, “so we really needed the larger Vistavision film format. Aside from the extra image size, another advantage with Vistavision was that since the film travels through the movement sideways, nothing needed to be below the lens. Normally you have spools and takeups below the lens — and a lot of Vistavision cameras do also — but Image G’s camera was specifically designed so that there would not be. This allowed the camera to virtually skim through the model at street level. Often the lens would be the element that protruded the most.”

Conditions within the warehouse were less than ideal for Barron and his lighting designer, Will Urie. Dust was everywhere and top-lighting tended to cut shafts through the floating particles. Even worse, the low ceiling reflected noticeably in the mirror finish of the river. Both problems were solved by shooting in-camera composites. “The first pass was with the overhead fill lights and the building lights,” said Goldberg. “We laid black felt on the river to eliminate reflections. Then we would pull the felt, turn off the top lights and



An even smaller-scale model was used for a scene in which the A-6 bombs its designated target before diverting over the city. Approximately thirty-five feet in diameter, the open terrain miniature — being dressed by Don Pennington — featured a small power plant protected by missile emplacements.



Overflight material was provided to Introvision where it was projected onto hyper-reflective Scotchlite screens and rephotographed with

shoot the site with the fiber optics, the little boulevard street lights and also a second exposure on the building lights just to get them brighter. So we got the site with the tiny lights reflecting in the river and that helped give the sense that there was water out there. On the power plant model we went with just a single pass. We didn't have problems with reflections because there were just little narrow rivers on that model." A 5K light was hung to represent the moon. Thirty to forty minutes were required to shoot each pass.

Many aerial scenes required 'chase plane' POVs of the entire A-6 against the terrain background with tracers and flak bursts creating dramatic interactive lighting. Others called for pilot POVs from the cockpit and actors to be inserted into miniature plates. While such shots are frequently realized with a traveling matte process, the Intruder effects team wanted instead a technique that would afford them the option to make real-time decisions about the aircraft movement within the frame and to see the final composite as it was shot. The choice of Introvision to accomplish such shots was instrumental in allowing the postproduction effort to trail off painlessly instead of escalating into the frantic scramble that characterizes most effects-laden films. "There was a lot of optical work involved in getting the Introvision plates ready," Vargo emphasized, "and that kind of reversed the usual pressure on the postproduction staff to get that done and approved. Introvision is like a Polaroid visual effect. It's a production tool rather than a postproduction tool. I saved money with Introvision — for better shots than we could have gotten otherwise. I think it was perfect for this movie."

The first major film effort to showcase the Introvision process was *Outland*. Since then, the company has done countless television commercials and in recent years has contributed sequences to such varied feature projects as *Stand By Me*, *Driving Miss Daisy* and *Darkman*. Under company president Tom Naud, Introvision has branched out into almost all areas of special effects to meet the complete needs of a production in-house. It is the Introvision process, however, that remains the centerpiece of their operation.

Whereas front projection entails positioning actors and props in front of a hyper-reflective Scotchlite screen onto which background imagery can be projected through a beam-splitter without registering on the subject, Introvision employs a second smaller screen positioned at right angles to the camera to position the subject convincingly within the plate. "At the same time that the image from the projector goes through the beamsplitter," said effects supervisor William Mesa, "it is also reflected off of the side of the mirror and refocused on the small screen. The camera then views the image on the front screen at the same time that it sees the image reflected off of the side of the beam-splitter toward the side screen. By matting areas on the small screen, the stage subject can be inserted into the plate. Introvision can also create a shot that is bigger than you could normally afford to do or a shot that is larger than the stage. That's because it's a dual screen system and anything that is not seen up front is still seen on the side screen. We're also able to block out whatever we don't want the camera to see up front on a large pane of glass." Apart from merely blocking out the reflected image, glass matte paintings can also be introduced. "With Introvision you can see the comp through the camera

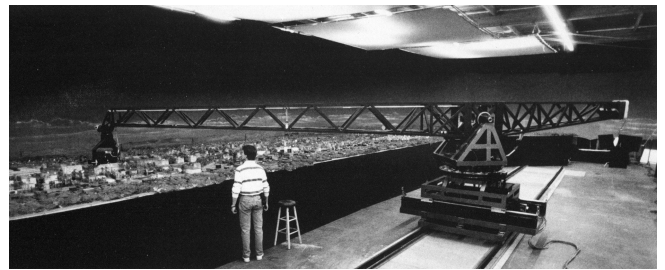
foreground aircraft miniatures. Introvision was employed for other scenes as well. With a minimum of full-size set pieces, large-scale battle scenes incorporating live-action and miniatures could be accomplished.

viewfinder. The lighting effects are tied together in the plate as well as tied together on the actors. You can't do that on bluescreen shots. You can't have the image quality up there to see how to do those exact lighting ratios and matches. We can even use smoke on different shots to soften the picture. That's impossible with bluescreen, too. Since you're shooting live you can do a variety of tests with very quick setups. In a day's time, the amount of shots we can get out is really incredible."

Months of work were required before the actual stage shoots could be performed. "First we went through a series of tests on the Pennington model to get it lit right for the best quality plate. We used 5296 film stock, which we found looks best if overexposed and underdeveloped. Doing that tightens the grain and produces better shadow detail. We did the same thing on the live Introvision stage." Before the stage work could be accomplished, Introvision had to animate anti-aircraft fire into their plates. But before even that could be done, they had to wait for the production to provide them with the cut sequences — which came late. "Normally you don't start compositing without an approved cut," said Vargo. "That rule is really inviolate in visual effects. But since the approved cut was late, during the last month before the shoot, Introvision animated and optically precomped the tracers and flak in all of the scenes for the process work — which was an extraordinary effort."

"It was definitely the most optical work we had ever done," Mesa confirmed. "When the airplane is doing maneuvers, there are all kinds of countermoves going on and the perspective changes so radically that it was pretty hard to do hand animation. We had to work out programmed prospective moves for the tracer fire, so the comps were quite complicated. We had one scene with the hospital where we had fifty-five lines of tracer fire in a frame — and it's all a compound move. When you multiply that by four seconds — the length of the shots — it's a lot of figuring out to do."

While traditional rotoscope animation was employed for tracer fire, the Introvision flak bursts involved multiple passes on a small red light hanging inside a thin ball of black cotton. "The little light source created an explosion effect in the middle. We had some live stage pyro effects, but the majority of the flak we put in the plates. We used a go-motion technique to get blurs as they were going by. The rockets were actually animated by hand. We tried a couple of different gags. We did a little cloud tank stuff and we tried some matte reveals on artwork. But the thing that ended



Hired as director of photography for the Hanoi plate shoot was Tom Barron of Image G who installed his company's motion control camera crane — the 'Bulldog' — on seventy-five feet of precision track laid parallel to the model. Camera assistant Paul Guglielmo inspects the clearance of a compact eight-perf camera built specifically for the project to allow rooftop-level passage over the set.



up as the final source were motion controlled moves where we hand-animated cotton."

Introvision is capable of precisely matching plate moves by using coordinate data from the motion control computer used in shooting the footage. Bill

Mesa did not consider that necessary for the Intruder effort, opting instead for generic moves that could be matched fairly simply by hand. A shot of the A-6 passing by the hospital demonstrated the flexibility of the Introvision process. "We did the comp plate," said Mesa, "adding the tracer fire and the airplane to the background of the terrain and the hospital." On their effects stage, Introvision added a man in the foreground at the top of a tower, tracking and firing at the passing warplane. The background plate was a panning move and the tower was rotated to match the movement. The result is the impression that the camera is moving around behind the soldier, following his turn to track the A-6. "It's a fairly complicated shot if you think about it, because the motion is tied to the background pan. The platform had a pivot in the middle and casters on the side. The whole shot was three seconds in which we had to move about eighty degrees. Normally we would use stepper motors and tie the projectors and everything together, but it was so fast that we did it by hand. The gunner was firing wildly and he shot through one of the tower posts. So we had one of them cut out and rigged for an explosion."

Two other shots were typical of the type of work Introvision is most often called upon to do. The first employed a plate of the hospital with concealed anti-aircraft guns that engage the A-6 during its overhead passage. Introvision added life to the model shot by inserting soldiers into the foreground who also fire on the Intruder. A few set pieces and actors with the projected image of the plate on an otherwise empty stage provided the illusion. Introvision prepared the plate for another shot showing a ZSU-23 armored vehicle and an anti-aircraft artillery gun firing on the plane before they are hit by bombs. The tracked vehicle and gun were built in quarter-scale, allowing for more realism in the explosions and mechanization of the gun recoils. Gas discharges through the barrels were ignited to create muzzle flashes. The effects house was to add people into the foreground and a man in the cupola of the ZSU-23. The projected image was so large that only essential portions fell on the primary Scotchlite screen. The missing segments were recorded off of the side screen. A large pane of glass between the camera/projector rig and the screen provided a surface on which black paint was carefully applied to conceal from the camera such things as the platform on which the tank commander was standing. "The body of the tank was blocked out up front," Mesa illustrated, "and it came through over on the side screen. So the guy standing out on the stage looked to the camera like he was standing inside the tank. In the foreground we added a real machine gun nest and we had a live explosion that tied everything together. You really couldn't do this for real with people anywhere near. The danger and cost factors would be quite high."

Much of Introvision's work involved refilming — through the A-6 windscreen — miniature terrain material enhanced with tracers, flak and missiles. Ordinarily this would have been complicated by the common rule of thumb which dictates that the stage subject be no less than half of the distance from the screen to the camera/projector rig to avoid fringing. Normally the

Multiple camera exposures Advanced Hued effects
build restorable vivid long illuminated
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employed a light painting river surface.

projector and camera are mounted together on a gimbal platform with projection and filming through a beam-splitter. A different arrangement was used for the cockpit setups, with the projector and camera widely separated on the stage floor. “We call it closeup Introvision,” Mesa explained. “With this process, the actor can move anywhere in the frame — including all the way up to the camera — without fringing. The projector off to the side is lined up to reflect its image off of a large pane of glass to be focused on the screen.” The high-quality glass panel, filling the entire frame, is placed at an angle in the middle of the stage between the camera and the screen. In this instance, the camera — in line with the glass and the screen — filmed from behind the cockpit mockup and through the canopy plexiglass. “The camera was free to pan, tilt and zoom. The thing that this process allows you to do over standard front projection is to introduce smoke, reflections or anything you want between the camera and the glass without affecting the projected image at all because the image is on the other side of the glass. Plus we can add a lot of shake and vibration which you couldn’t do with a standard comp shot. We also have a higher quality image than normal front projection because we’re shooting through a straight piece of glass and not going through a beam-splitter. I’ve shot everything; and this is definitely, by far, the highest quality you can get out of any process.”



For a number of shots considered too problematic to attempt otherwise — specifically surface-to-air missile encounters with aircraft — Mark Vargo determined that computer generated imagery might be an option and hired Rhythm & Hues to explore the possibilities. After a promising first test the company proceeded to build detailed digital models of both aircraft and missiles and then choreograph them in 3-D computer space. Enhancements of a more organic nature — such as smoke and tracer fire — were also simulated electronically. For action over the Hanoi cityscape — see title page — the computer aircraft was composited digitally over plate material that had been photographed on the miniature set and then scanned into the computer.

Some of the most complex effects shots in the film consist of the A-6 shown against the Hanoi background with the confusion of anti-aircraft fire all about. It was the advantages of the Introvision process for these critical scenes that had drawn Mark Vargo to the company. Introvision built their own twentieth-scale A-6 models for the stage shoot. Plastic kit models in forty-eighth and hundredth-scale served for long shots of the aircraft. Two of the twentieth-scale miniatures were built — a 'hero' model and a 'stand-in' for tests. "Larry Jolly built the basic fuselage," Mesa recounted. "All the add-on details we did ourselves. It had little lights in the cockpit that shone on the pilot figures to match the on-stage work." The horizontal tails and spoiler motions were realistically tied together and the model was suspended on wires from a marionette rig attached to a tracked boom arm. The principal components of the rig were twelve radial arms with tip rollers to guide the marionette wires. The array was approximately four feet in diameter and incorporated two stepper motors, each actuating a pair of vertical bars which moved opposite to each other. "As the motor rotated, it pulled the cables up on one wing while lowering the other wing. It could do about forty-five degrees of angle change. We used all twelve of the wires to make a very tight, stable rig. You could actually go over and knock on the plane and it would go right back to its stable position immediately.

"If you look at real air-to-air photography, there's a sense of the camera behind having a hard time keeping the plane up front in frame. That's the kind of motion we were trying to simulate. We're capable of shooting it in two ways. Everything can be designed as a free axis or random move — or we can motion control all of those moves and axes. The overall system can roll the plate, pan, track in and out and move crossways. The camera itself is free to pan, tilt and zoom. Besides the plane axes, the whole marionette rig could rotate, raise and lower and track. We used just about every axis possible to put the shots together. Once we lined up everything to a proper vanishing point or perspective on the plate, anything we did was true to the aircraft's position. In fact, it was kind of like flying a real plane."

One of Mark Vargo's boldest decisions was to employ computer generated imagery to achieve some of the more troublesome aerial warfare footage. It marks one of the first occasions in which high-resolution, photo-real computer animation of a nonfictional subject has been incorporated into a cinematic production. "I used CGI for shots that I couldn't do with radio-controlled, real or miniature airplanes," said Vargo. "And the shot that I found was the hardest — which as far as I know has never been done before — was a decent surface-to-air missile encounter with an airplane. What I wanted was to shoot the miniature backgrounds and then have someone use CGI to insert the missiles, the missile exhaust and the A-6."



Pleased with their night work, Vargo gave Rhythm & Hues an additional daytime shot in which the digitized A-6 dropped a shower of Snakeye bombs over a jungle target. As the bombs fall away from the aircraft, fins deploy to stabilize their trajectory. Motion blur was incorporated electronically.

Vargo chose Rhythm & Hues to produce the footage. The small Hollywood production company was formed just three years before by John Hughes and Charles Gibson — both Abel group alumni — to perform general effects work while using their extensive computer capability as a foundation. In its short existence, Rhythm & Hues has garnered much respect in the field of television commercials, winning several prestigious awards. “One of the advantages of CGI for a film like *Flight of the Intruder*,” John Hughes enumerated, “is that we are free of mechanical constraints. For instance, there is a scene in which there are bombs under the wings. The bombs release; and as they fall, the Snakeye attachments deploy. For us, that’s a very straightforward thing to do, and yet it’s pretty difficult for model people. Another advantage is our ability to control the choreography of many objects in a scene. Our ‘camera’ in the computer is infinitely small and can go anywhere. We can preview in real-time as many objects as we want in a scene and get the movements just right. And we can composite in the computer with complete control over the image. We can see the results in minutes instead of waiting for film to be processed.”

“The look can be much more organic now,” said computer graphics designer Clark Anderson. “We can add textures, like dirt, to elements to make them look more real, less synthetic. If an element is moving quickly, we can add a little motion blur to soften it a bit. For night footage like we did for *Intruder*, we can do interactive lighting, blend colors, add textures and really make the element an integral part of a particular scene.”

To win the contract, Rhythm & Hues did a video-resolution test using the same Image G plate material employed by Introvision. “The footage was transferred to tape and was read into our computer in digital format,” Hughes explained. “Then we encoded an A-6 and flew it down the street, over the model. We created the airplane with water condensation off the wings and smoke coming out of the engines — which you wouldn’t normally see — and composited it as a night scene. That’s what we showed to Mark, and he decided that it would be appropriate to do the smoke effects in the computer. We can create the hard-edged models fairly easily. The really hard effects for us to do are organic — smoke, tracers, things like that. He picked what for us was the most difficult thing in the test.”

The Rhythm & Hues team approached the work with a combination of enthusiasm and trepidation. “Mark went way out on a limb,” Hughes confessed, “there’s no doubt about it. He definitely took a risk in asking us to do this. It’s the first time we’ve actually had to work at feature resolution and make it cut with other elements. It was kind of scary. But it was a night scene, and it was all fast cutting and fast moving — which helped.” There were, however, certain limitations. “Explosions are so organic that they would have been very hard for us to do. So Mark shot them live and we comped them into the final scenes.”

The process began with storyboards provided by the production. “Clark Anderson redrew the initial boards,” stated Hughes, “making them slightly more complete for our purposes. Then Min — our modeler — built the A-6 inside the computer. For reference, we had physical models of the A-6 and we also got blueprints. Min, when he encodes, looks at the storyboards and tries to determine what he has to build with extremely high detail and what he can build at lower detail. In the original boards, we never had to get under the wing; so Min didn’t put a lot of

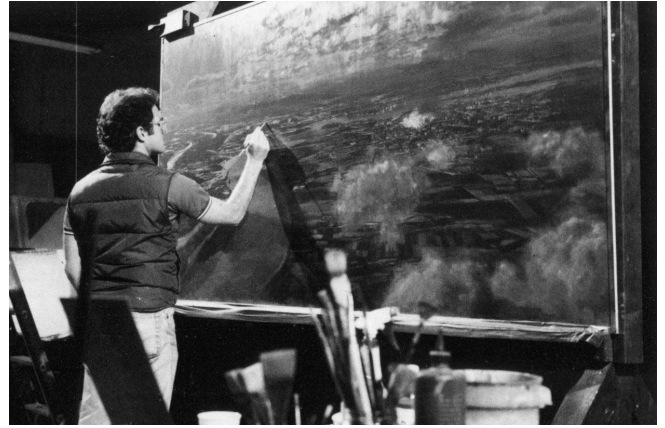
detail into that area. Once we started choreographing, however, he realized that we were getting much closer to the airplane than he had ever thought we would; so he had to go back and rebuild parts of the model with a lot more detail. Once Min was finished, Clark went in and painted — essentially ‘airbrushing’ footprints, dirt and everything else onto the surface to make the plane look more realistic. It still wasn’t complete at that point because we needed to see what we were cutting with and what we were comping into before we could really define the lighting. Next we created a wire-frame animatic on the computer. The animatic simulated in 3-D what was happening with the A-6. We simulated the landscape, the A-6, the SAM and all the distances and speeds. Then we shot those onto videotape or film and Clark and our editor, Rick Ross, cut the pieces together to create a sequence. Something that’s realistic from a scientific standpoint isn’t necessarily going to capture the sense of excitement you want for a movie, however. So Clark and Mark Vargo would get together and look at the footage from a dramatic point of view. If there were things they didn’t like, we would go in and change them.”

Rhythm & Hues was required to combine their elements with the terrain model backgrounds being photographed with the motion control rig. “If computer graphics and motion control are going to work together,” Hughes emphasized, “it has to be very tightly coordinated. Then, as the camera moves, the perspective changes accordingly. If you just arbitrarily try to put several things together, the moves won’t be identical and they’ll slide against each other. After a movement was settled upon, we would begin to do some simple renders. We needed to render everything fairly quickly — not perfectly lit and not with all the smoke effects, but just to get the feeling for the volume of the airplane moving through the frame and to see whether Mark still liked the motion. In the computer, we added our elements to the backgrounds, rendered the scenes at relatively low resolution and shot them to film so that Paramount could start cutting those into their workprint.”

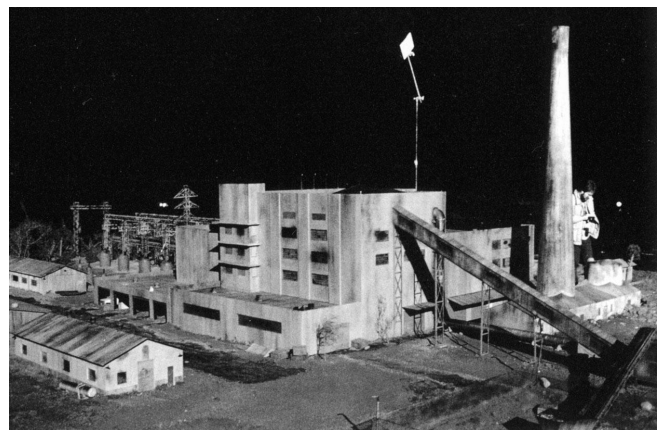
Once the moves were satisfactorily rendered in low resolution, it was necessary to repeat the process in more time-consuming high resolution. The first step was to transform the motion control background plates into a form that could be utilized by the computer. “The transfer of the plate to digitized format creates its own problems,” stated Hughes. “You need to scan at film resolution — not video resolution — and at that point in time our scanner was not yet operational. The computer graphics facility at ILM was the only one that had that capability. We enlisted their help and they were very generous in doing it for us.” Digital compositing offered many advantages over the standard optical approach. “With digital compositing, we have total control over contrast, intensity, hue and saturation — everything that’s needed to manipulate the image and make it integrate into the film. That doesn’t mean it’s easy, though. Day-for-night would be difficult for us to do — but no more difficult than it would be for optical people. We comped more than twenty scenes in the computer for *Intruder*. In five years, everyone will be doing their opticals digitally.”

Bluescreen elements were also composited digitally. “The scanner provided the red, green and blue records directly,” explained optical supervisor Bert Terreri. “A higher gamma blue record was generated to create a matte — the inner matte — that blocks out all of the bluescreen in the frame. The computer allowed us to see gamma changes in the different records immediately without having to shoot and process film. Like any bluescreen photography, when working with glass or metal you still have to worry about blue spill — but you are guaranteed not to get matte lines. Digital compositing has many other advantages as well. When a good optical house does a bluescreen shot, recreating a rich black without increasing contrast is always a problem. Usually the detail is lost. With the computer, the gamma and contrast of the plate are totally independent from the creation of the matte that removes the bluescreen. Thus the contrast level can be wedged as an independent function. Also, digital compositing uses much less film. There is no black-and-white processing and generally much less wedging because you can see the composition on the RGB monitor.”

“Bert Terreri coordinated all of the animation and wedging with Mark,” Hughes resumed. “When they were satisfied with the wedges, we rendered the scenes at high resolution and shot them to film. We use a film printer which puts the image up on a CRT and we shoot it through a red, blue and green filter. The resolution of that screen is eight thousand dots across and eight thousand lines — four thousand line pairs — so it’s a very high resolution screen. Somewhere between two and three thousand lines is the limitation of what film can resolve, and it becomes senseless to increase the resolution anymore. What limits us resolution-wise is computer time. If you render at higher resolution, it takes up more space in the computer and it takes longer to process. If you double the resolution, the length of time goes up almost by a factor of four because you have four times the area and four times the number of pixels. At this point in time, we can economically render at 35mm resolution. This is approximately twenty megabytes of information per frame of film. We typically don’t render at the resolution of Vistavision. Instead, we render at 35mm Academy resolution and then shoot it



A computer generated A-6 was optically composited over a multi-element matte painting rendered by Michael Pangrazio and Chris Evans of Matte World. The painting — representing a pullback view of the now-distant Hanoi missile complex as the A-6 makes its escape — was accomplished on glass and employed backlit moire patterns to simulate city lights. Also incorporated were superimposed fire and smoke elements.



Explosions were an integral part of the raid. Designated targets — such as the power plant that is attacked prior to the run on Hanoi — were constructed as large-scale miniatures and photographed outdoors by Slagel Minimotion.

onto Vistavision film. Shooting is just forty-five seconds a frame, but rendering it will usually take an hour.” Several days are typically required to complete each scene. A total of four months were expended to produce the approximately two minutes of computer generated material in the final film.

Vargo was sufficiently impressed with the Rhythm & Hues nighttime imagery that he decided to take the process one step further and asked them to attempt a daylight scene in which the Intruder passes beneath camera while dropping Snakeye bombs into the jungle below. Convincing motion streaks and precise matching of the plate lighting was essential in selling the shot. Bert Terreri remembered the reaction in the screening room at Paramount. “It went by everybody. Milius said, ‘We didn’t shoot this.’ Everybody wanted to know where it had come from.”

Because of the preponderance of shots requiring tracers and similar effects, Vargo eventually had five vendors working on animation opticals — Available Light, Introvision, Rhythm & Hues, ILM and R&B Films. Available Light — operated by John Van Vliet and Katherine Kean — provided the lion’s share of the tracer fire. “Most of what we did was pretty simple stuff and done in a very old-fashioned way,” Kean allowed. “We did muzzle flashes, interactive lighting and bombs dropping on a tank — but most of what we did were tracers. The production provided us with videotape of tracer footage from Vietnam for reference. We found that when a tracer leaves the source it can be very long — up to two and a half times as long as the barrel of the gun. That was a problem because it tended to make the tracers look like lasers — especially in tight shots where they extended from the muzzle right to the edge of the frame. Milius was insistent that they not look like something out of Star Wars, so we had to do a lot of enhancement — like putting interactive light bursts on the smoke and also on the tank. We found that the interactive light, though nearly subliminal, seemed to have as much or more impact than the actual tracers. So by increasing the interactive light and bringing down the tracers until they were almost invisible, we were able to keep the effect from looking too much like laser beams.

“The first shots we did were during the daytime. In that case, we had to grad down the sky so that the tracer would show up better. It takes a lot more exposure and you have to be more careful about artwork on such shots because you need to diffuse it some to get the right look. Most of the time there was enough foliage and the background was dark enough so that the tracers could be seen well. Usually we just inked the tracers in black on white paper and shot right from the paper on hi-con film stock. The tricky part was matching the camera moves since the tracers are disconnected from the background. On each frame we had to figure how much the camera moved and how it affected the tracers. The flak had a very soft edge so those were done on cels and backlit. Essentially it was a very soft fuzzball for one or two frames and then became a thin wisp of black smoke. Because it has kind of a bright explosion first and then a dark cloud, we combined toplit and bottomlit elements. We also shot the bright burst as a reflection when the plane goes over water. Some of the flak was shot go-motion under the Oxberry so that it had a streak to it.”

Only two matte paintings appear in the film. The first was a complex shot showing the A-6 roaring away from Hanoi after the bombing raid. The aerial view was provided by Matte World,

a Marin County firm recently formed by ILM alumni Michael Pangrazio and Craig Barron. Matte World was given the assignment in early March with about a month to produce the Vistavision footage which ran approximately one hundred frames. Pangrazio and another ILM veteran, Chris Evans, rendered the painting on a four-by-eight-foot glass sheet. A moire pattern for the city lights was scribed into the paint and backlit. Gels and a spinning aluminum foil wheel added flickering realism to the lights which were recorded on a second exposure. Barron supervised the filming of a high-speed fire and smoke element shot at night outside the studio. "The element was projected onto the painting as a double exposure," Barron explained. "The white smoke photographed against the black background without a problem, but a white card was inserted for the pass on the fire. There's a suggestion of reflection on the river, but we didn't want to distract the viewer from the main action of the fire and the airplane." A pullback on the matte painting combined with the Intruder racing toward the audience caps the climactic Hanoi raid. The A-6 — complete with wingtip vapor contrails — was supplied by Rhythm & Hues as matte elements with Pacific Title completing the composite. It was the only airplane in the film composited through traditional means.

The second painting was accomplished quickly and economically. "In the story," said Vargo, "Jake and Cole see a TV news spot with a Swiss journalist in front of the SAM missile emplacement in Hanoi. Matthew Yuricich painted that background. The whole piece was shot in video and we had to put the guy over the painting. We painted a blue cyclorama and used outdoor light. So it was an outdoor bluescreen shot comped in video. We had only about a week to do it and then shipped it straight to the carrier for the first unit to use."

The bombing of Hanoi called for large static miniatures and pyrotechnic effects which were photographed towards the end of the postproduction schedule at a remote location in the hills south of Redlands, California. Most of these miniatures were built by Pete Slagle and his Slagle Minimotion company, although Don Pennington took on a number of structures as a subcontractor. The coal-fired power plant that is bombed prior to the attack on Hanoi was built in twelfth-scale and stood five feet tall with a twelve-foot smokestack and was the focal point of a fifty-by-fifty-foot set that included barracks buildings, rice paddies, fabricated palm trees, power transmission arrays and an adjacent large-gauge model railroad which was part of an extensive preexisting network to which the location was principally devoted. The shot called for three explosions outside the plant and two inside the building which would blow out the windows and skylight. The action was recorded with three highspeed cameras hidden within the set and by a fourth camera placed on a hill above it. Another camera was 'flown' on a wire strung between two hills and slightly offset from the site to obtain an over-the-shoulder perspective from the departing plane. A carefully balanced tenth-scale A-6 model — built of fiberglass using a mold pulled from an existing model — crossed the set on a single wire running on bearings within the plane and was catapulted by a sixty-foot slingshot bungee cord to streak over the structure at about forty miles per hour. The filming was conducted night-for-night with the crew shivering in bitter cold February temperatures.



Buildings surrounding the Hanoi surface-to-air missile complex were constructed in twenty-fourth-scale by Slagel Minimotion and Don Pennington. A fiberglass A-6 was mounted on a single wire and rigged to a bungee cord slingshot device that catapulted the aircraft over the set at about forty miles per hour. All shooting was done at night.



Cameras are readied for a low-angle view of the A-6 passing over the missile emplacement.

Once the power plant footage was achieved, the set was struck to make way for the similarly large-scale 'SAM City' replica which consisted of a tree-lined city square surrounded by prominent government buildings and a battery of surface-to-air missiles for the defense of the Hanoi. In twenty-fourth-scale, the set included seven principal buildings, about a dozen lesser structures and approximately one hundred SAMs with accompanying transporters, erectors, crates, tents and radar vans. "All the buildings around the square were modeled after actual Hanoi buildings," Dave Goldberg observed, "although they were not necessarily placed precisely where they belonged. The People's Resistance Park — an area where wrecked American airplane parts were displayed — was moved to the opposite side of the street. Also incorporated were moving elements including some cars and an electric trolley. The trolley was motorized and had interior lights, and the cars were pulled on wires." Practical lighting illuminated the setting. The boulevard down which the Intruder flies fed directly into the square, so a portion of the avenue was built at one end with an additional ten feet or so suggested by street lighting only. A catapult wire rig like the one erected over the power plant was employed to fly the A-6 model over the set.



For the master shot in the sequence, some fifty individual explosions and other pyrotechnic effects were employed to produce a profusion of primary and secondary blasts.

The climactic destruction of SAM City included about fifty individual explosions and other pyrotechnic effects. Eight primary charges were buried under the square, and minor secondary explosives were scattered among the SAMs and vehicles. A few of the missiles were equipped with model rocket motors so that when ignited, the models would slither violently amidst the wreckage. "The charges were on a timed board so that the detonations would progress in a predetermined sequence," Goldberg explained. "I asked for some charges to produce flames as if from gasoline trucks or something blowing up and igniting the front of the buildings. In one shot, the A-6 is flying down the boulevard and a missile passes by just a few feet away and dives down into the city. Then we cut to a shot of a building with it going in. So there was a small charge in one of the buildings to simulate an explosion. Except for that, the buildings themselves did not blow up. There was a scene in which the plane goes swooping by the front of a building and the Vietnamese shooting at it end up hitting the building. We had talked about actually firing a BB machine gun at the front of the building, and sections of it were built with plaster for that reason. However, the sequence was changed and the scene was cut."

At the point where the boulevard enters the square, a camera was mounted just a few inches above the street with a mirror attachment on the lens that allowed the field of view to be much lower to the ground. "That particular camera picked up the plane while looking up," Goldberg said, "and followed it by rotating down so that you were looking at the square as the A-6 was flying away with the camera actually pointed at the ground. For that flyover shot, we also had two other low cameras at the far corner of the square. For the main blow, we had the aerial camera, a camera by the buildings looking into the square, a low camera similar to the flyover shot, and a dug-in Vistavision camera at the head of the square with a miniature tent over it for

an Introvision plate. We got all the cameras running, and when the flyover camera was over the square, that was the cue to start firing the charges. Later we did a bunch of insert shots of individual things blowing up.” Lighting for the extensive miniature included small lamps concealed in the foliage to illuminate building facades, two 10Ks with diffusers for fill, and a 12K HMI on a crane above the set — representing the moon — to serve as the key light. “We were shooting at one hundred twenty frames per second so it really darkened down quite a bit.”

Two eleventh-hour miniature shots had to be picked up with just a few weeks of postproduction remaining. Since John Milius was not completely satisfied with the radio control A-6 explosions, Pete Slagle was given the task of producing Boxman’s finale — a fiery descent through the sky. Mark Vargo also had to put together a quick Intruder scene for the film’s opening episode in which Grafton and McPherson are on a routine bombing mission when Morg is hit by a small arms round. “As a button to their struggle to get back on the carrier deck,” Vargo illustrated, “Milius wanted a shot where the A-6 is right on top of the camera and catches some of the lights from the deck. We did that by hanging one of the Slagle planes on wires and adding some movement. We hand-held the camera and pushed underneath the model on a dolly. We built a little carrier from a kit, had strobe lights added and did the same thing approaching the deck from the top. It was all shot in one day.”

The last shots trickled in early in June. “We started out with one hundred twenty-two shots,” Mark Vargo recounted, “and ended up with close to three hundred because of decisions made by the director during postproduction and editing. About sixty shots were eventually edited out — mostly tracers. Even so, we were only about \$500,000 over budget — for more than twice as many shots. It was just an absolutely remarkable experience for me. I did more things than I imagined I was going to do, plus I was able to try approaching visual effects more like first unit production. Because we were on the lot and because we had our own editing room, if we spotted a problem or wanted to make a suggestion we could go right to the editors or the director himself. Ordinarily, effects people can’t make cutting suggestions. I think it’s definitely the first movie where, as visual effects people, we were included in the fold of first unit work. There’s a marriage there that I think is creatively necessary and essential for economically producing shots.”

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CLASH OF THE ROBOTITANS

article by

Jody Duncan

Of all the superheroes born and resurrected in the movies in the past fifteen years, none has battled in a more corrupt arena than Detroit's RoboCop. Introduced in the successful 1987 film as the ultimate corporate answer to mounting crime and street violence, RoboCop was a cyborg created of high-tech robotics and the earthly remains of one Alex J. Murphy, deceased Detroit police officer. Impeded somewhat by brief flashes of his own humanity, RoboCop nonetheless followed his directives — to serve the public trust, protect the innocent and uphold the law — and cleaned up the streets of a near-future Detroit that made Gotham City and Metropolis look like children's playgrounds.

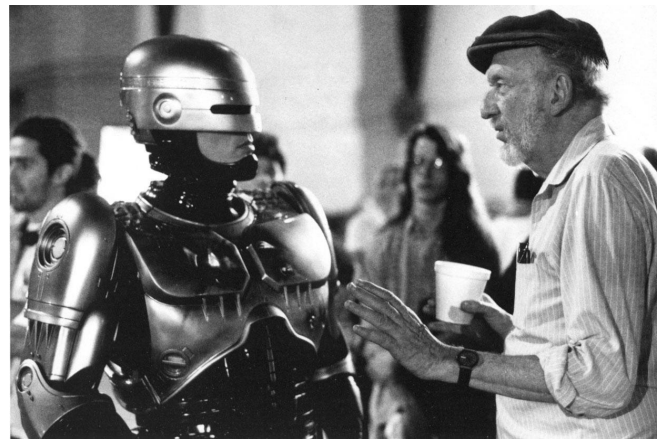
RoboCop, directed by Paul Verhoeven, proved to be so popular with audiences — grossing more than \$50 million domestically — it was inevitable that the Orion Pictures release would soon become a candidate for sequelism. Orion approached RoboCop producer Jon Davison with the idea soon after the film's release, but unwilling to be involved in a sequel without a fresh and exciting approach to the RoboCop story, Davison declined. "Initially," recalled Davison, "I said 'no.' I just didn't have any ideas for a new RoboCop at the time, and I was already involved with Dick Tracy. So I told them to do it without me."

Planning to go ahead with the sequel in spite of Davison's absence from the project, the studio hired Edward Neumeier and Michael Miner — who had written the original screenplay — to begin work on a new story. Months later, when Neumeier and Miner turned in a first draft that was unenthusiastically received by Orion executives, the studio again solicited Davison's participation. This time, he accepted. "By that time, Dick Tracy had gone to Disney and it was Warren Beatty's movie all the way. I'm sure I would have been able to contribute, but RoboCop

image



The streets of Detroit get even meaner in RoboCop 2 as former police officer Alex J. Murphy — now a cyborg defender of law and order — matches wits and firepower with a gang of vicious drug dealers and an advanced law enforcement prototype designed to be his replacement.



Actor Peter Weller — returning in the RoboCop role — confers on the set with veteran director Irvin Kershner. Also returning were most of the original effects crew members.

2 was an opportunity to do my movie, to have a lot more input than I would have had on Dick Tracy. So I left that project and RoboCop 2 began to interest me again.”

That interest led to a four-month stint working closely with Neumeier and Miner on a completely new screenplay. The revised story was developing nicely when, suddenly, Neumeier and Miner left the project to write another film. It was a serious blow to the effort since a Writer’s Guild strike which was in full swing at the time precluded Orion from hiring new writers. Fortunately, Davison’s production company, Tobor Pictures, was able to sign an interim agreement with the guild which allowed the producer to bring a new screenwriter onto the project.

A fan of The Dark Knight — the gothic ‘comic novel’ which explored the Batman legend and served as inspiration for Tim Burton’s 1989 film phenomenon — Davison approached its author, Frank Miller. “I felt that The Dark Knight had the same sort of edge that was required for RoboCop 2,” Davison commented. “I liked its humor, the politics, that dark edge, the inventive action. Frank seemed like the ideal choice; and, luckily, he wanted to do it.” Miller — who had been fascinated with the character of RoboCop in the original film — embarked on a screenplay that would further explore the complexities of that character. He had just begun to draft the script, however, when Orion mandated a summer of 1990 release date for the film. Davison was left with less than a year to complete a film that had not yet been written.

Undaunted, Davison began recruiting key personnel for the production, assembling virtually all of the effects veterans from the original film. When it was learned that Paul Verhoeven was unavailable, Davison hired director Tim Hunter, who had recently completed The River’s Edge — a quirky chiller that had been critically well received. “I thought River’s Edge was terrific,” said Davison. “Tim is a very realistic, naturalistic director, and that is what makes fantasy pictures work. I thought he would bring a lot to the material. Tim began working with Frank — and, in fact, he was the one that came up with the story point of the foreclosure of Detroit, which I really liked.” During this period, Walon Green — a veteran action writer with credits on The Wild Bunch and Sorcerer — was enlisted to join Miller in shaping the script. The project was progressing nicely — then disaster struck once more. A few short weeks before the slated beginning of principal photography, Tim Hunter bowed out of the project. “I think what scared Tim off was the fact that the picture had to start shooting, because of our locked-in release date, and yet the story hadn’t completely been licked yet. This release date was staring us in the face and Tim was worried that there just wasn’t enough time to get the script the way he wanted it.”

With Hunter’s departure, Davison was left with the unenviable task of finding a director who would be willing to step in at virtually the last minute. “It was a tough situation, because anyone I approached would have to go into the project knowing there was not a hell of a lot of time for his input. I was thrilled when Irvin Kershner said he would do it — especially since he has turned down a lot of pictures in recent years. I thought his Empire Strikes Back was the best of the ‘Star Wars’ movies. I met with him on a Friday, gave him the script, and said, ‘If you want to do it, you’re going to have to let me know right away, because we start on Monday.’ Luckily, he called me right back and said he would do it.”

By the time Kershner stepped in to helm the project, RoboCop alumni had already begun designing and implementing the various effects suggested by the still unfinished screenplay. Rob Bottin was hired to recreate RoboCop's armored bodysuit; Phil Tippett (who had worked with Kershner previously on the 'snow walkers' sequence in *The Empire Strikes Back*) returned to spearhead the monumental stop-motion assignment; art director Craig Davies was assigned the task of designing RoboCop 2; Peter Kuran of Visual Concept Engineering was brought in to execute, once again, the 'robovision' effects; and Rocco Gioffre returned to supply matte paintings. In addition, newcomers Michael Wahrman and Gregory Ercolano of de Graf/Wahrman were retained to produce the digital images that were central to the characterization of the new RoboCop.

Having already secured commitments from Peter Weller and Nancy Allen to reprise their respective roles as RoboCop and his partner, Ann Lewis, Kershner and Davison spent their few remaining weeks filling the other key roles. Tom Noonan was cast as Cain — a drugged-out, but charismatic leader of the violent drug cult. Daniel O'Herlihy returned as The Old Man — the chairman of the board of Omni Consumer Products. Belinda Bauer as misguided psychologist Doctor Juliette Faxx, Willard Pugh as beleaguered Detroit mayor Kuzak and Gabriel Damon as the adolescent drug dealer Hob completed the cast.

With cast and crew assembled, principal photography commenced against the glass and steel skyline of Houston — a change of venue from the Dallas location that had served as the futuristic Detroit in the first film. The location change was precipitated by a general lack of cooperation from Dallas city officials. "We found that they were very reticent to close down streets for us," Davison recalled, "or let us do our pyrotechnics. They were just not helpful when it came to our action sequences. Houston promised us a lot of assistance, and they came through. They were enormously cooperative, letting us do things that would have been very difficult to do elsewhere."

RoboCop 2, as finally scripted, begins with 'Mediabreak,' the evening news broadcast which suggests a Detroit — and, indeed, a world — gone even more awry since the last film. Bland, smiling news anchors (Mario Machado and Leeza Gibbons) report that the Brazilian rain forest has been destroyed by a nuclear accident. On the local scene, the Detroit police department is on strike; the city is near bankruptcy; and, on a humorous note, the still malfunctioning ED 209 that erroneously wiped out an entire boardroom of OCP executives in the first film has been sold as a law enforcement tool in five major cities.

Animation supervisor Phil Tippett orchestrated the stop-motion news footage of the bungling ED 209 being towed out of a manhole — and was even featured on film as the sanitation engineer directing the tow truck. A renovated model of the ED 209 from the first film was used for the sequence. "We just had to clean it up and give it a lube and oil change," Tippett remarked. "For the shot of ED 209 getting his foot caught in the manhole cover, we built a miniature set. We had a photographic background plate of the actual street to use as reference. We spent a great deal of time matching the color and the texture of the street so that it would blend into our model in the foreground. We also built little danger cones and signs to add detail to the model."

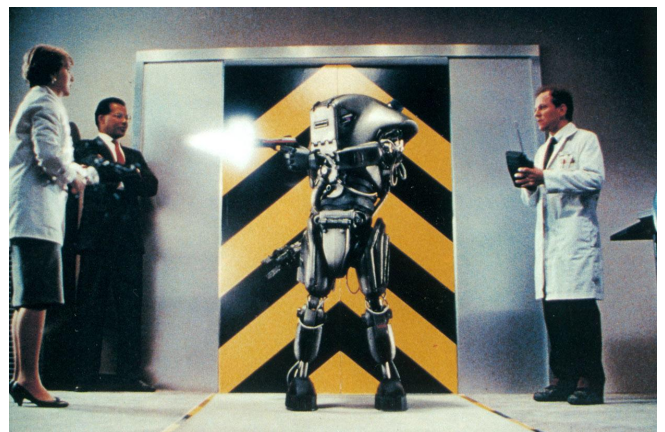
The news footage showing the nuclear destruction of the rain forest was created by matte artist Rocco Gioffre, who had provided the expansive paintings representing OCP's skyscraping headquarters in the original film. "The footage shows the jungle melting down," said Gioffre, "and I did that shot completely from scratch in Los Angeles. I got permission to go over and shoot at the Los Angeles Arboretum where they have a nice jungle area. We masked off the top part of the frame and shot an area of trees and palm leaves for the live-action original negative foreground. Then, later, I painted on the nuclear power plant and added smoke that was moving slightly, coming out of the stacks, and also some fire elements. The smoke was done on a sheet of glass in front of the matte painting — part of the smoke was on the background matte painting and part of it was on the foreground glass. I just moved it slightly east-west on a motor, rotating it in front of the painting. Since it actually went behind one of the matte painting trees, my matte cameraman Paul Curley masked off that part of the painting and then later on went back and put the same tree back in. So the smoke appears to be moving behind the trees." Fire elements were shot in a separate pass and then bipped into the shot.

The news broadcast goes on to cover a press conference in which the surgeon general warns the public of a powerful new recreational drug, Nuke — the most addictive drug ever created. A violent cult, led by Cain, has already formed to promote the potent drug, escalating the drug wars on Detroit's already near-lawless streets. With the city's police on strike, RoboCop mounts a single-handed campaign to bring Cain down.

Makeup effects expert Rob Bottin — who had designed and constructed the RoboCop suit for the first film — was called upon to do likewise on the sequel. He accepted the assignment even though he was still stinging from public criticism leveled at his earlier work by Peter Weller. "By the time we had finished the first RoboCop, the suit rumors were already flying fast and furious. In terms of Hollywood hype, it always sounds better to say that we conquered the unconquerable — so as time went on, accounts of the suit's poundage grew, as did the rumor that it was uncomfortable and impossible to move in. As for discomfort when wearing the suit, I can't imagine a robot suit — or any other type of bodysuit — being comfortable to wear. Frankly, it's just not a fun thing to do. Basically, the only area I thought we could improve upon was how quickly we could get Peter Weller in and out of the suit. If he could take it off



As in the first film, television newscasts — amply laced with black humor — are employed to reveal the horrid state of world and local affairs. In the opening 'Mediabreak,' vapid news anchors devote a sentence or two to report that the Brazilian rain forest has been destroyed by a nuclear accident. Illustrating the account was a matte painting produced by Rocco Gioffre.



in a few seconds and put it back on with the same speed, how could he be too uncomfortable? It is rare that a film's star is a character that wears a robot suit. Normally these characters are cast by using people who have a high tolerance for wearing and performing in these types of situations — they are certainly not 'stars.'

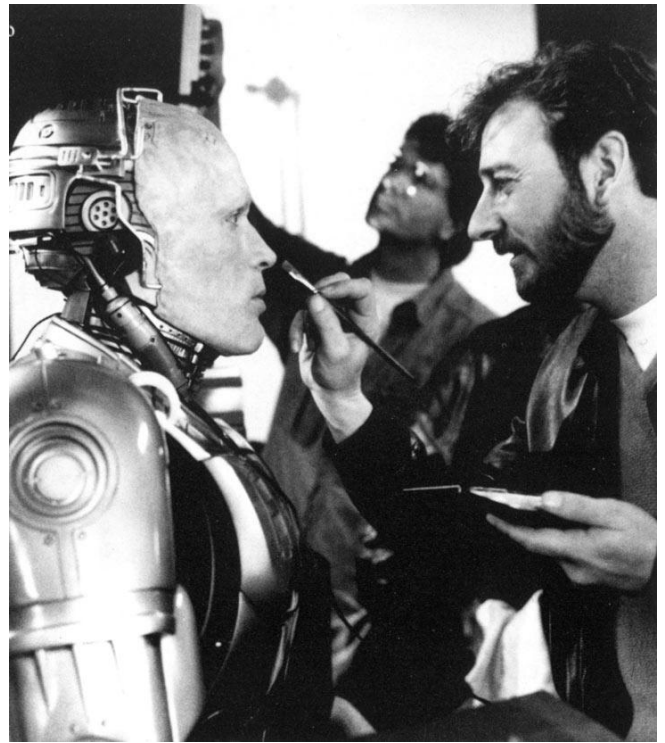
Attempts by Open Cinema to develop and animate the RoboCop by the Phil Tippett Company and the Don Williams selected one of the best motion picture's former organic states with their current mechanized ones. The first prototype deliberately kills two technicians and then shoots itself in the head.

"Actually, the notion of using a star to portray this character was quite daring. Peter Weller had serious reservations about 'acting like a robot' — which understandably would scare any actor. His concern became everyone's concern. In the end, though, after many discussions between Paul Verhoeven and myself, the decision stood. If the character did not move like a robot, he would only be a guy in a suit. We had to be brave and use our imaginations to 'hear' big sound effects over every one of Peter's overly-stylized movements. Just watch RoboCop on video with the sound turned off and you can sense the panic we all felt. We had to have faith that it would work — and inevitably, Peter had to have the most, because he was a star and could have looked like a fool. Finally, he went with the notion and, to his credit, delivered an incredibly powerful performance."

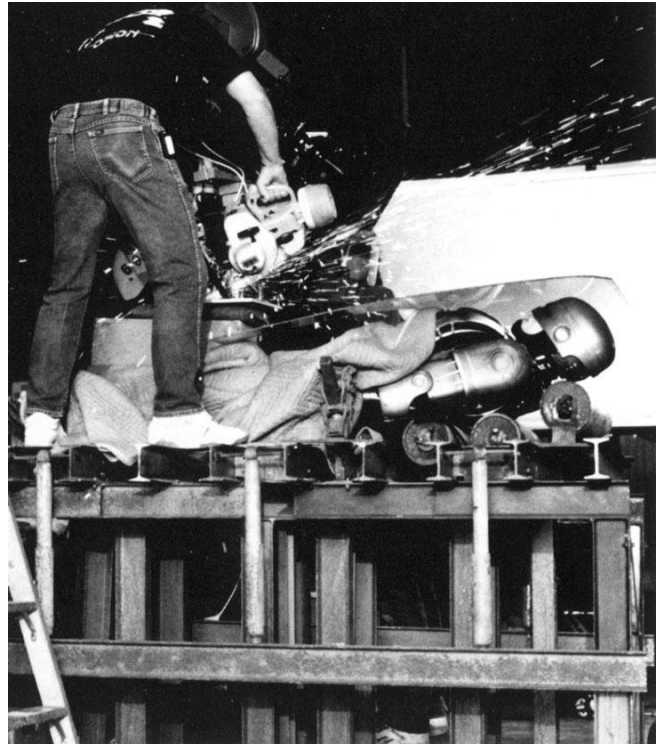
To achieve his objectives for the sequel suit, Bottin incorporated changes in both appearance and construction to the prototypical robosuit developed for the first film. The steel gray color of the original was altered to a bluer tone that Bottin believed would read better on film. And the new suit — unlike the original which was made of latex and fiberglass — was built solely out of fiberglass. This refinement afforded greater mobility and also shortened the amount of time required to get Peter Weller in and out of costume. "Getting Peter into the suit on the first film did take a long time. And once he was in it, it didn't make a whole lot of sense to let him out until he was through. But designing the most flexible robot suit ever used in a film was a large enough task for Round One. That left simplifying the application as a fun problem to solve in Round Two — which we did. Coming up with a system to achieve that was a movie job in itself, and could only be done through trial and error, research and development — which we had time for in RoboCop 2. The best thing about creating and designing RoboCop was the fact that once we had built the suit, the job was still not over for me. There was still the difficulty of bringing it to life by collaborating with the actor, the director, the cinematographer and the sound effects expert."

Another carryover from the first film was the 'robovision' effect which was used to illustrate the cyborg's point of view. To create the effect, Peter Kuran of VCE resurrected the technique he had implemented in the original RoboCop. "We generated graphics on a Macintosh computer," said Kuran, "and then scanned them into the computer printer. Lynda Weinman was responsible for generating the computer images. We scanned a line-up chart into the computer, just digitizing it into a file. Then, using that same line-up chart, we would register it against the print of the scene so we knew where things would go in the frame. At that point it would be transferred back to film and then we would composite it over the shot." To suggest the presence of video scan lines, fine India ink lines were hand-drawn on acetate by Jammie Friday and composited over the shots.

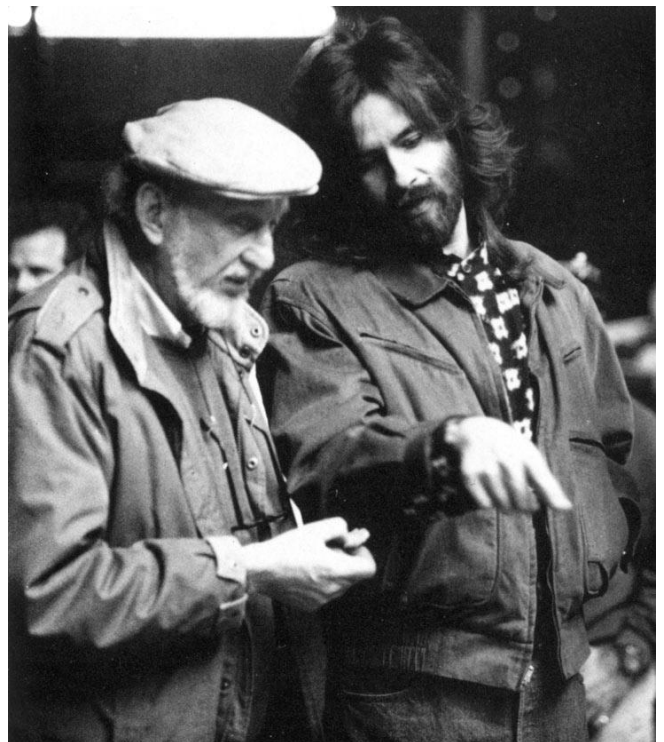
Certain scenes required an electronic interruption of the imagery to represent the malfunctioning of RoboCop's brain circuitry. Characteristic pops and glitches in the images were photographed off of a television monitor. "At the time of the original RoboCop," Kuran recalled, "I tried to get the effect in the video process, but all the video technicians at the video houses kept saying: 'What?! You want to screw up the image? You can't do that!' They gave all sorts of reasons — like the signals will all be lost and you just can't make it roll or glitch out. Now it is a very popular thing — you see it in a lot of commercials as a way of getting people's attention. But at the time I had to come up with another way to do it. So I would just get the live-action scene transferred to videotape, then play the tape on a video monitor and photograph it off of that, screwing up the television picture to get it to jump and pop. I photographed off of a twenty-six-inch Sony monitor, playing with all of the knobs — vertical and horizontal and tracking — to get it to jump as much as possible. Photographing off a monitor worked fine because the image wasn't supposed to look that good anyway."



For the sequel, makeup effects creator Rob Bottin incorporated refinements into the original RoboCop suit design that greatly simplified the process of getting the actor in and out of it. As in the original film, several sequences required the character to appear without his helmet. Makeup artist Stephan Dupuis adds final detailing to the full appliance conversion.



Overpowered by the drug cult he has pledged to eradicate, RoboCop is assaulted with jackhammers and cutting tools. A plexiglass panel protects the actor as the camera shoots through a shower of sparks.



Irvin Kershner and Rob Bottin confer on the set.

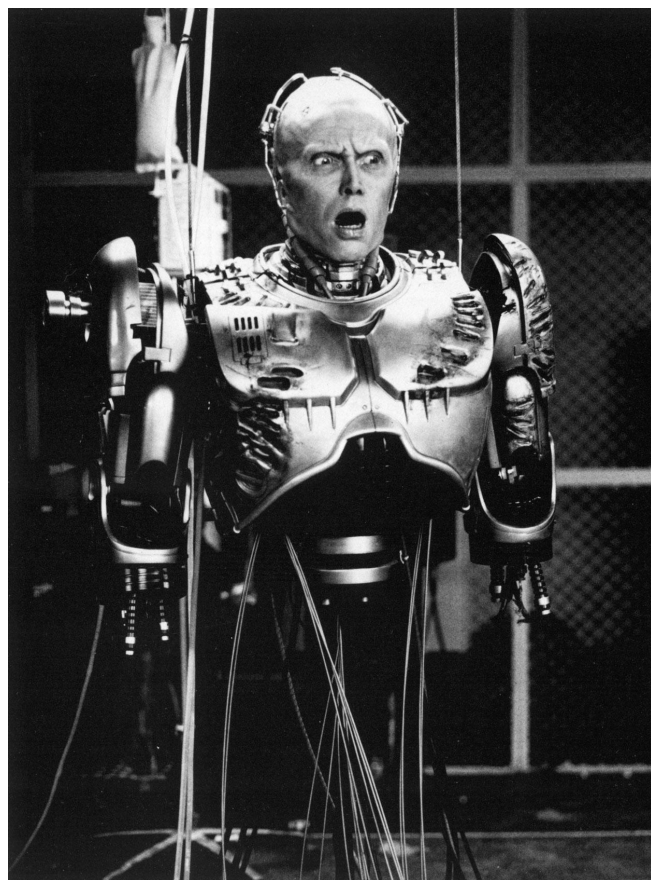
In addition to occasional glitches, the robovision material required computer generated readouts. “There is one shot where RoboCop has something like an ASCII disturbance — just meaningless symbols going by. I wrote a program for that and shot it off of my IBM computer monitor. There is one line in all the gibberish that says, ‘Avoid Orion Meeting,’ but only one person I know of actually noticed it. There are also some hexadecimal codes for computer whizzes to decipher.”

Though he is haunted by the memories and feelings of his life as Alex J. Murphy, RoboCop has been a resounding success as a law enforcement officer. In RoboCop 2, Omni Consumer Products attempts to repeat that success, producing two new and ‘improved’ RoboCops — both of which prove to be dismal failures incapable of making the psychological transition from man to machine. The two failed prototypes were designed by Craig Davies. “What we were trying to do with these models,” Davies remarked, “was show the progression from the original RoboCop to what finally succeeds as RoboCop 2. The failures were also meant to illustrate the fact that these scientists didn’t have their shit together — these things just didn’t work. They were really supposed to be sort of black humor jokes, too; so we tried to make them funny and low-tech. In designing them, I thought in terms of what would be the most terrible thing to have happen to you, and that led me to the two designs — one was a head that has been chopped off and stuffed inside a diving bell; the other was a person completely encased in metal, with only little slits for eyes and a slit for a mouth and nothing more.”

Working from Davies’ designs, modelmaker Paula Lucchesi sculpted the twelve-inch models out of clay. John Reed then molded them in cast urethane. Armatures were designed by Tom St. Amand and machined by Blair Clark. “Paula did most of the detailing on the puppets,” noted Davies. “She painted them and added all the little



Dismantled in pieces, RoboCop is dumped in front of picketers at police headquarters.



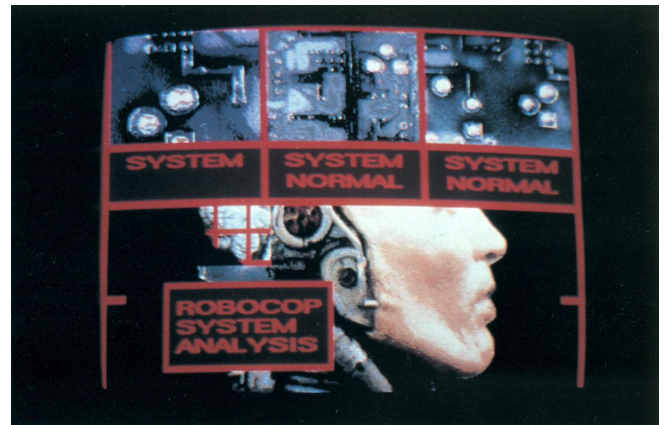
For subsequent scenes of the cyborg in his life-support chamber, Bottin and company produced a fully mechanical puppet to represent the

wires to them. Then I went in and airbrushed them a bit to add some highlights and shadows.”

traumatized law enforcement unit in his stripped-down form.

A tiny rear process screen was incorporated into the diving bell model, allowing an actual face to be projected in from behind for a shot of the distraught cyborg shooting himself in the head. “It is a closeup shot in which his visor opens up and then he shoots himself,” said Davies. “Phil Tippett photographed my face for the shot, and that is what was rear-projected into the model.” The head of the second RoboCop prototype was constructed from a small plastic skull that was found in the model shop. Little white beads were painted and applied for eyes, and the top of the skull was then sawn off to allow a miniature brain and wiring to be inserted.

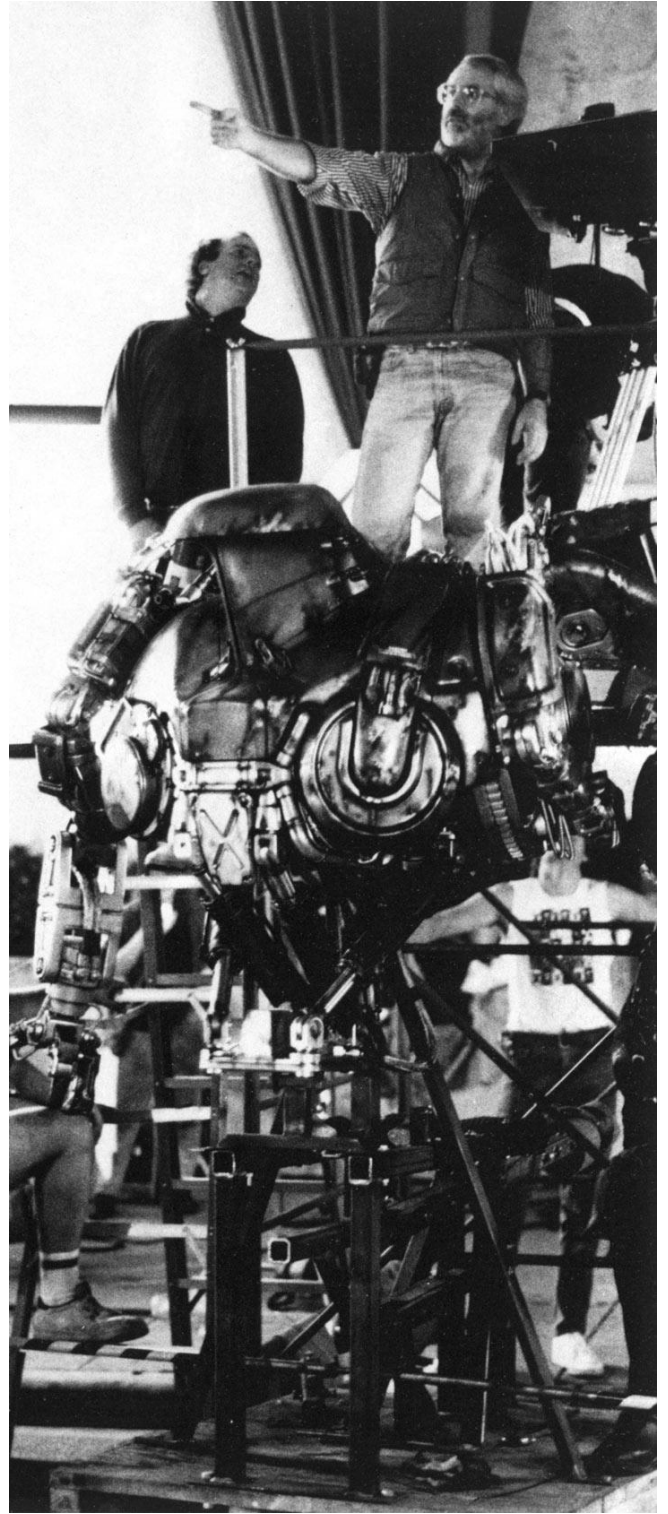
The sequence commences with one of the OCP scientists enthusiastically introducing the new RoboCop models. Thick metal doors then open to reveal the supposedly state-of-the-art law enforcement officers. Don Waller stop-motion animated the puppets, as well as the doors. “We just matted in a phony door onto our miniature set,” said Tippett. “Peter Jamison made up two doors for the live-action — one that was open and one that was closed — but we handled all the actual, physical opening and closing with stop-motion. Sometimes they were full-scale doors, sometimes miniature — it depended on the shot — but in all cases when the doors were moving, it was stop-motion. Dealing with live characters crossing over in front of the models was complicated. We got around that problem by engineering the cut so that the live-action door would be open or closed. Then, in the transitional scenes — when they were physically opening or closing — we would cut to our stop-motion doors.”



To determine the extent of damage done to his circuitry, technicians study a computerized representation of the cyborg's brain on a monitor in the life-support chamber. A three-person computer graphics department headed by Paul Sammon employed an Amiga 2000 personal computer to render the material expeditiously for on-set use.



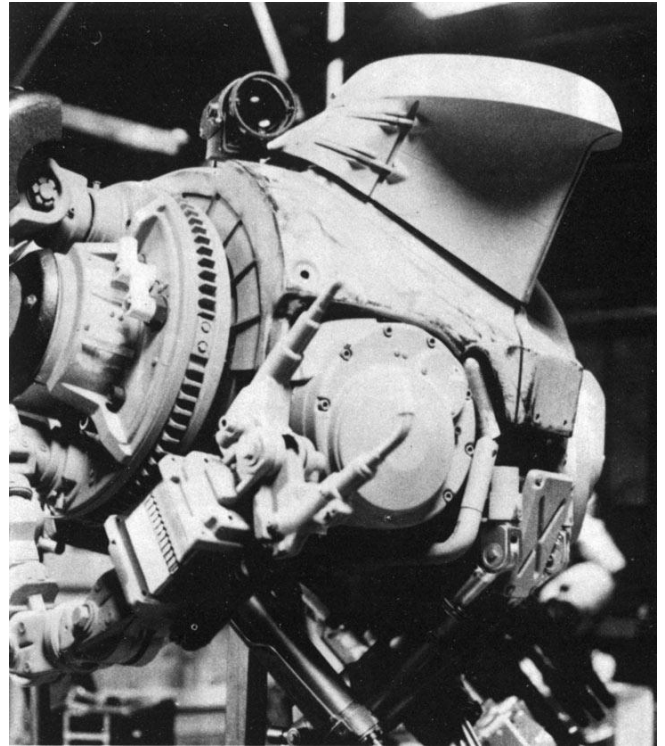
Similarly produced readouts were featured throughout the film — including an operating room scene in which the prematurely deceased drug lord Cain has his brain removed for use in a radical new cyborg concept



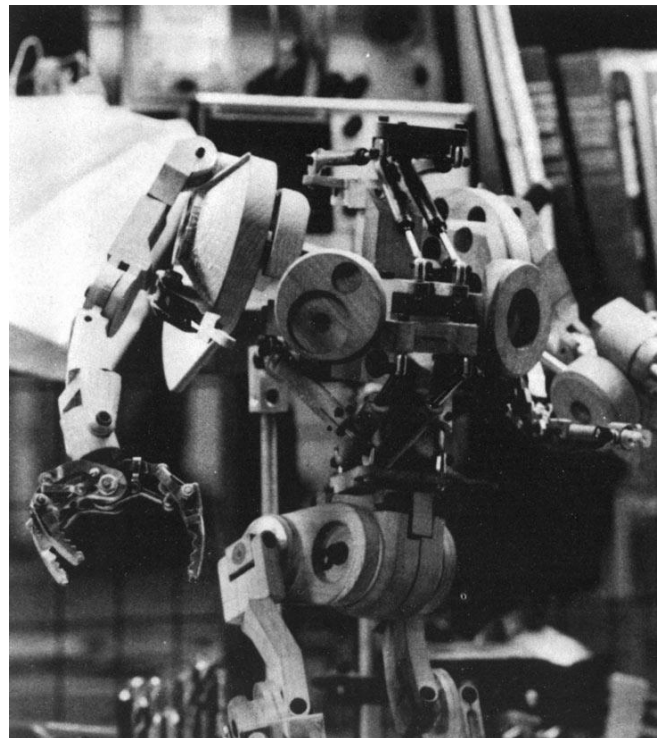
Effects art director Craig Davies designed the gargantuan RoboCop 2 — half of which was built full-size for use on the set. Director of photography Mark Irwin prepares for a down-angle on the killer machine.

While his obsolescence is being engineered none too successfully at OCP, RoboCop continues his single-handed campaign to apprehend Cain and stop the manufacturing of Nuke. But when he finally encounters the drug lord and his gang at their hideout, RoboCop is overpowered and systematically dismembered — stripped down to nothing more than a head and chest by way of drills and cutting torches. Mechanical body sections were featured for the most part; but for closeups revealing RoboCop's face, precautions had to be taken to avoid injuring Peter Weller. Sparks from the cutting torches were introduced into the live-action footage by placing sheets of clear plexiglass between the sparks themselves and the actor. Additional sparks were introduced at VCE via cel animation. "Kevin Kutchaver animated the sparks coming off of the torch when the gang was cutting off RoboCop's hand," said Kuran. "All that was in the original footage was a little halogen light, so we added the sparks to that and also some interactive lighting on RoboCop's face from the torch to make it look like it was really there. We projected the image down and then rendered the animation basically with pencil and paper. The original negative was used as a printing element, and we made a cover matte to hold density."

Stripped and barely alive, RoboCop is delivered in pieces to police headquarters. Carried inside to his life-support station, the near-dead crimefighter is suspended upright on cables and subjected to a battery of diagnostic tests. The task of producing the dismembered cyborg — a full puppet replica of the character as he appeared unhelmeted near the end of the first film — fell to Rob Bottin and company. "It was the most exciting thing we were asked to create for RoboCop 2," Bottin affirmed. "The effect was fun because it is very easy to dismantle RoboCop — there is so much suit and hardly any flesh. A cable-controlled RoboCop meant that we could eliminate Peter Weller's body

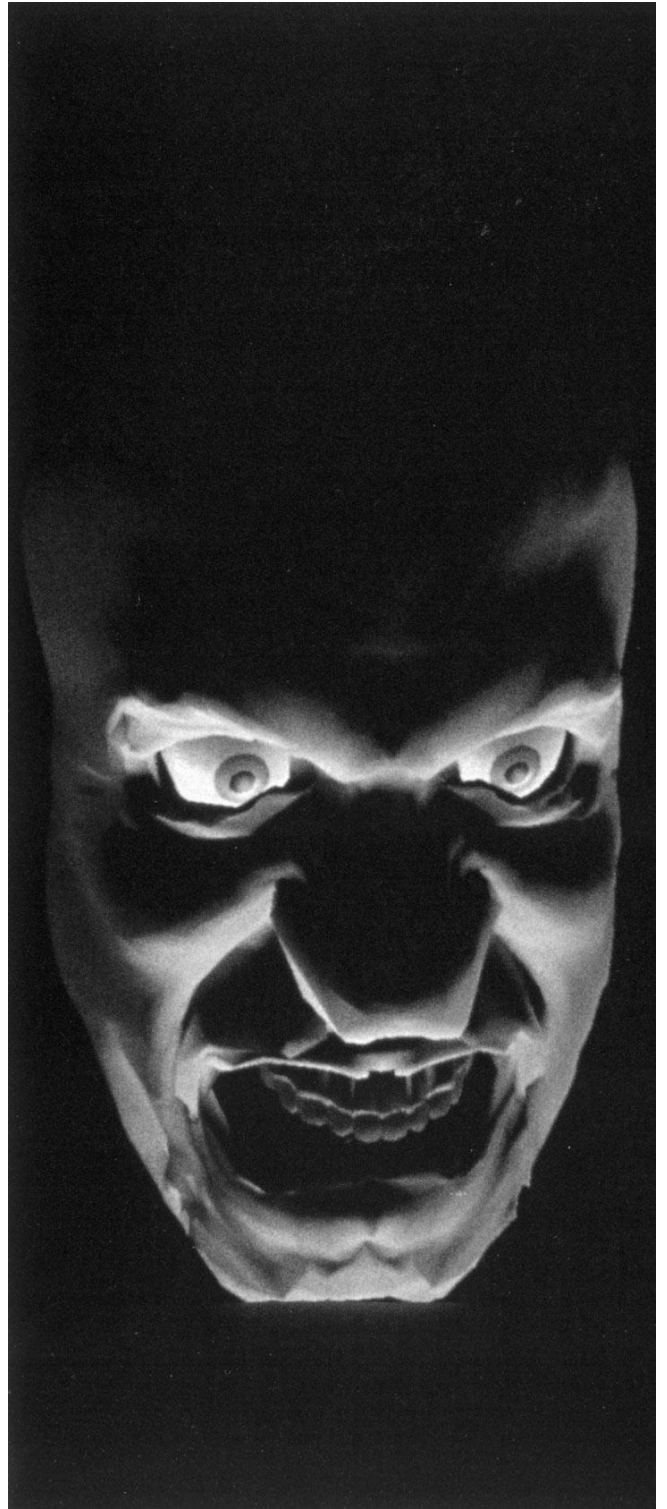


The full-size torso under construction.



Most of the RoboCop 2 scenes employed a complex stop-motion puppet. A foot-tall wooden mockup — fashioned by Davies — was used by Tom St Amand to design the final armature which was machined from aluminum and stainless steel.

down to a legless, armless torso and have his third act makeup mechanically brought to life — which would be inoffensively nightmarish. The torso was suspended by a winch normally used on a jeep, and the cables — which controlled the torso — could be visible, doubling for RoboCop's life-support system. A small TV monitor ejected from his bicep to read out prerecorded graphics indicating systems failure. In terms of the mechanical animation, we used a series of cable-controlled mechanical devices to move eyes, jaw, neck and arms — all of which could be performed to achieve the effect that RoboCop was in a comalike stupor. When we tested it in our facility, it was perhaps the most emotionally disturbing effect I have ever been involved with. It seemed so real. It was as though our hero was truly dying. It really lets you know that he is part man and part machine — and at a certain point he is not invincible." Twelve operators were required to articulate the puppet on camera.

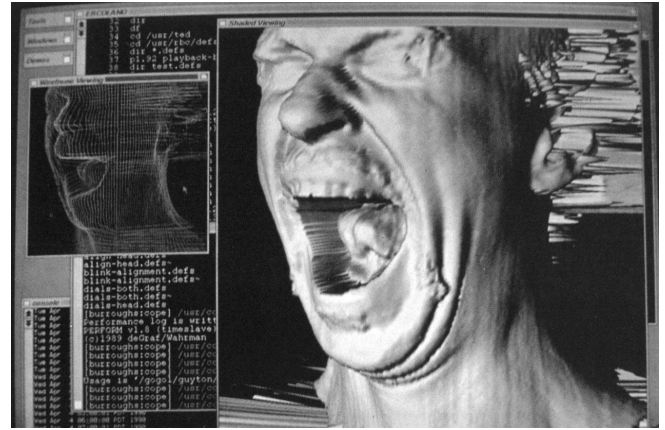


Within the armored helmet of RoboCop 2 is a monitor on which a digitized representation of Cain can be seen raging in frustration at his fate.

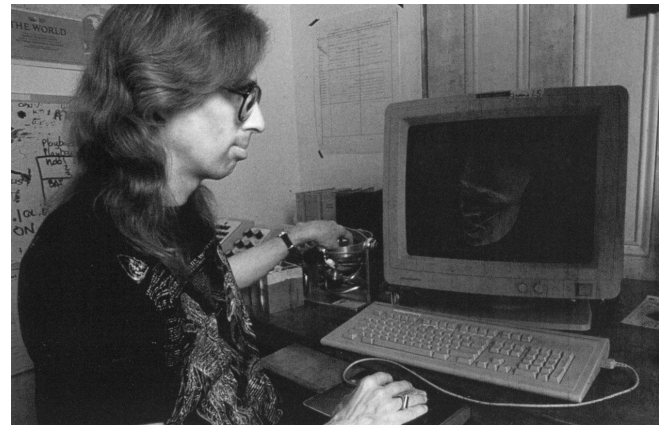
As the torso hangs from its support harness, RoboCop's brain is treated with electric microshocks to keep it functioning. In order to ascertain the damage done to his circuitry by the brutal assault, the robotechnicians study a computer graphics rendering of the cyborg's brain on a monitor. This and many other background computer graphics featured in the film were generated quickly and recorded live on the set rather than being added optically or as inserts during postproduction. "I went to Jon Davison with the idea of using the Amiga 2000 — a personal computer — on the stage during principal photography as a means of filming the various computer graphics for the film," said computer graphics supervisor Paul Sammon. "Ordinarily, computer graphics are added in postproduction by a video or optical house which employs dozens of people and has an enormous amount of overhead. These facilities can spend two days to eight weeks generating a single image on film. My idea was to try and do these computer graphics running on stage during principal photography. And instead of using high-end systems, we would try to produce the vast bulk of computer graphic imagery on a home computer — albeit one which is capable of very sophisticated video graphics."

Davison approved the idea and Sammon contacted a local hardware and software outlet — Microsearch of Houston — which supplied the production with a basic Amiga graphics system. "They also put us in touch with Mike Ribble, a local computer graphics artist. Mike and I, plus Brian Kinzey — the video playback operator — comprised the computer graphics department on the film. Our primary responsibility was to paint in some of the drab spots in various corners of the set by pumping up the video imagery. But Irv Kershner became very excited about the possibilities of this graphics system and he had Frank Miller actually begin to slightly alter the script to more prominently feature the animation and graphics we were producing."

The on-the-set computer graphics played a significant supporting role in the robochamber sequence in which RoboCop hangs, near death, on wires. "The computer graphics begin with a side view of RoboCop with his helmet on. The helmet then peels away to reveal what he looks



Computer generated imagery was created for the segments by de Graf/Wahrman utilizing a unique real-time approach. Facial topography was obtained by laser-scanning actor Tom Noonan in a range of expressions and then feeding the resulting data into a Silicon Graphics Iris computer where the imagery was refined into stylized three-dimensional representations.



A series of joysticks and waldos allowed multiple puppeteers to effect changes of expression directly on the graphics monitor. Once the choreography was fully developed and locked in, the imagery was photographed on film stock and transferred to videotape and then laserdisk. Electronic sculptor Ken Cope tinkers with the system.

like underneath. The forehead and skull of RoboCop are next removed graphically on screen to reveal the naked brain underneath which was then segmented and microscopically examined for the various circuitry that could have been damaged during his brutal encounter with Cain. One of the chips in RoboCop's brain zooms out, expanding and filling the screen; and underneath it, a system indicator flashes on and off, saying 'System Damage.' The entire graphics sequence was done on the Amiga 2000. We took a piece of artwork of RoboCop in profile and began to add on the various layers of brain circuitry, crosshatching and system readouts that were used in that sequence. We were able to produce almost two minutes of animation within a matter of two days." Ultimately, the personal computer approach contributed thirty-five minutes of computer graphics to the film.

Determined to keep the troubled city as lawless as possible — thereby insuring their takeover through foreclosure — OCP restores RoboCop, but programs him with directives that render him incapable of violence. Operating under these new directives, RoboCop becomes an ineffectual robowimp. In order to erase the restrictive directives, RoboCop risks electrocution by thrusting his hand into an electrical substation. The high-voltage surge successfully erases the programming and RoboCop, back in form, sets out once again to stop Cain. The police are inspired to leave their picket lines and a bloody battle in Cain's drug lab follows — a battle in which Cain is seriously wounded and hospitalized. Having decided that Cain's twisted mind has the perfect psychological profile for the new and improved RoboCop 2, Dr. Faxx disconnects the drug lord's life support system, making him an unwilling, but formidable recruit.

Though Cain expires seconds after the disconnect, it is soon apparent that his raging criminal mind lives on in RoboCop 2. The 'Cain monster' is introduced on film as little more than a television monitor on which a bizarre, digitally-produced caricature of Cain appears. "The idea of the TV screen in the helmet," said Craig Davies, "was that it was — as Phil Tippett put it — the window to Cain's soul. Initially there were to be three TV screens in the monster. Dr. Faxx was going to enter the monster herself and then she and Cain would fight for control of the body. That internal conflict was to be shown on these three screens. Eventually, the concept was simplified and we wound up with just the single TV screen to show Cain inside this thing."

A foot-tall model of the upper portion of RoboCop 2 was built for the closeup shot of the television monitor whipping out of the helmet. Inside the model, a two-inch diameter Sony LCD television was mounted on a mechanism that would allow movement on three axes. "Michael Steffe built the mechanism that moved the television out and around," said Davies, "and Marc Ribaud, Merrick Cheney and Paula Lucchesi built the puppet. That one had only the television mechanism and some functioning lights — it didn't have to do anything else." A mid-sized puppet — two feet tall — was also built for the sequence. "John Reed and I devised a way to physically enlarge a smaller model into the intermediate size so that we could build a new model quickly and easily. We soaked one of the smaller models in materials that made it expand, then took a mold off of that, cast it up, and it was a perfect scale replica."

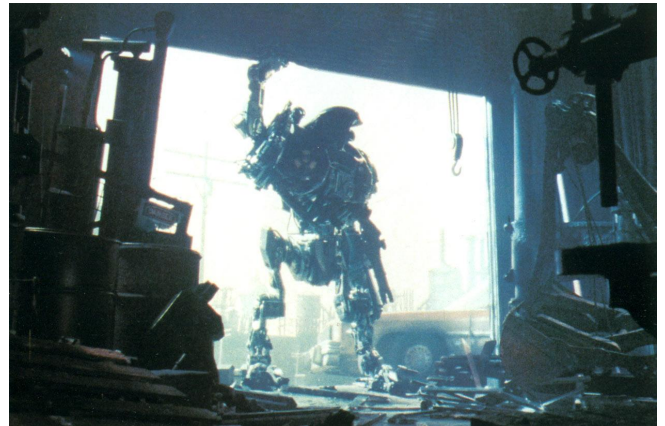
The digital image of Cain on the monitor was a computer graphics effect which utilized a new technology pioneered by deGraf/Wahrman. Jon Davison had approached the computer graphics company after seeing their live demonstration of a digitally-generated talking head. "Jon saw our demonstration," said Michael Wahrman, "and told us he wanted much the same kind of

effect for RoboCop 2. He gave us a script — which at that time had many scenes in which the digital image of Cain actually spoke dialogue. Ultimately, the dialogue was dropped and we wound up with a Cain image that was expressive but did not in fact speak.” Tippet gave deGraf/Wahrman a shot-by-shot breakdown of the sequence, outlining the desired action of the digital image with Trey Stokes, who would be performing the computer puppeteering.

The first step in producing the computer graphic imagery was to laser-scan actor Tom Noonan in a variety of expressions. The scanning was done at the Cyberware Laboratory facility in Monterey, where a number of laser-scanned busts had been produced for a variety of applications on such films as Star Trek IV and The Abyss. “The actor sits in a chair on a platform,” explained Wahrman, “and the laser is on an arm that spins around his head for about ten seconds. So Tom had to hold each expression for ten seconds while the laser was scanning. He did smiling expressions and expressions of incredible rage — just a whole range of things. We were able to catalog quite a variety of expressions in only five hours. Then we gave them to Irv Kershner and he chose the ones he liked. The next step was to create high-resolution maps that conformed to those expressions.”

The data resulting from the laser scan was fed into a Silicon Graphics Iris computer. “Of the four dozen or so heads that we had scanned,” said technical director Gregory Ercolano, “we ended up using only four or five. We had a smiling head, a screaming head, one with a neutral expression, and one or two others. We use a program called ‘Correlate’ to essentially shrink-wrap a mesh onto the data. Ken Cope is our chief sculptor and it was he who moved all the polygons around on the face and tweaked the details of the eye and mouth folds, making each of the heads look as good as possible by cleaning up any hashing in the face and trying to emphasize the musculature.”

When the digitized heads were satisfactorily tweaked, they were then puppeteered using a software program called ‘Perform.’ “The program is set up by assigning all of the dials on the



When the mayor of Detroit agrees to a clandestine meeting with the new drug lord to negotiate a deal that might stave off bankruptcy for his financially destitute city, Omni Consumer Products — anxious to foreclose — sends RoboCop 2 to disrupt the proceedings. The resulting confrontation was one of two major stop-motion sequences executed by the Phil Tippet unit.



Much of the RoboCop 2 footage was staged in virtual darkness to maximize the visual impact of the walking juggernaut. Halogen lamps

computer to specific movements,” said Ercolano. “There were eight dials all together: two joystick boxes that had two dials on each which were used primarily for eyebrow movements and other small expressions; then, we had what is called a ‘waldo,’

which has dials attached to it. We can actually put our hands into the waldo and move it around; and as it moves, all of the dials attached to it pick up the positioning of our hands. It allowed us to do the rotation, tilt forward and tilt back of the head. The puppeteering is a kind of interpolation process — if you’re interpolating a scream on one dial and a smile on another dial, you can get a mixed expression of the two. So we could get a lot of acting out of just the four heads that we had.”

Once the dials had been assigned, the puppeteered actions were broken down into separate passes. “For instance, the positioning of the head and the mouth opening and closing might be the first pass. Then the second pass might be the movement of the eyes and eyebrows, and the third pass yet another effect. So for each pass, we would rerun the one just before it and then progressively record new things until all of the actions were built up. We manipulated the whole thing in real time, right on the computer screen. We were getting about eight frames per second real-time playback speed.” The final animation was photographed on 35mm stock using an Aztec film recorder. “We basically shot it right off of the Silicon Graphics screen,” said Ercolano. “The resolution was 1280 by 1024 lines, which is pretty good considering the final result would go to NTSC video — which is about half that.”

The film material was next transferred to one-inch videotape. “It was treated with noise reduction on video,” said Craig Davies, “then transferred to laserdisk. We wanted it on laserdisk so that we could stop it on a single frame without hurting it. Two laserdisk players and a video mixer were hooked up to the little two-by-three-inch LCD television in the puppet. The mixer allowed us to puff up colors, interject noise and add the little white blip that appears when the screen first opens. So we were really able to tailor the stuff and give it some life.”

For Michael Wahrman, the computer imagery in RoboCop 2 was an opportunity to challenge the limits of the technology. “What we set out to do was perform a character live with a computer. The question was, could we find a body of people who could create characterization in real time — was that talent pool there? And the answer was yes. We also wanted to establish that someone could direct us without knowing a lot about ‘traditional’ computer animation. Phil Tippett was able to direct the animation even though — as far as I know — he has never worked with computer graphics before. But he was able to direct it and seemed quite happy with what he got. We found that we can create pretty good characters and we can create a lot of them. Now the challenge is to create a character that has a bigger part.”

The digital imagery reveals Cain as a raging beast, still hopelessly addicted to the drug of his own making. In an effort to control the monster, Dr. Faxx offers a supply of Nuke — which the cyborg eagerly takes by way of a feeding mechanism designed by Craig Davies and built by Michael Steffe. “It is basically a claw that opens up and takes the Nuke inside,” said Davies. “At one point there had been a flamethrower in that area — which was the robot’s crotch — but Kershner thought that was toilet humor and got rid of it. So when it was decided that this thing

incorporated into the puppet design, cut beams of light through the dusty environments to achieve the desired effect, two stop-motion stages were sealed off and filled with smoke during the protracted shoot. Animator Justin Kohn steps aside during a frame exposure.

had to have an entry point to take the Nuke in, that was the natural choice. The little claws themselves were very much like the smaller claws that arachnids use for feeding. There was a push-pull mechanism to pull the door down, and then a pulley wheel and a lever to slide the claw forward. Then there was another handgrip-type assembly that would apply tension so that the claw could actually hold the container of Nuke. It was retracted by the same mechanisms, only in reverse. Nick Blake operated the feeding mechanism; another person operated the door; and then one more person operated the claw. I swung the robot into place, and someone else was blowing smoke. So it was an elaborate, five-person setup. We shot it on our insert stage at high speed against a white background.”

RoboCop 2’s first mission for OCP is an assassination attempt on Mayor Kuzak who is resisting corporate takeover of Detroit. Hoping to make a deal that will save his city from bankruptcy, the mayor has agreed to meet with Hob — the twelve-year-old drug dealer who, upon Cain’s death, has ascended to the leadership of the Nuke cult. Their meeting at Hob’s warehouse hideout becomes a bloody massacre when RoboCop 2 arrives on the scene — and the awesome size and power of the Cain monster is finally revealed in full.

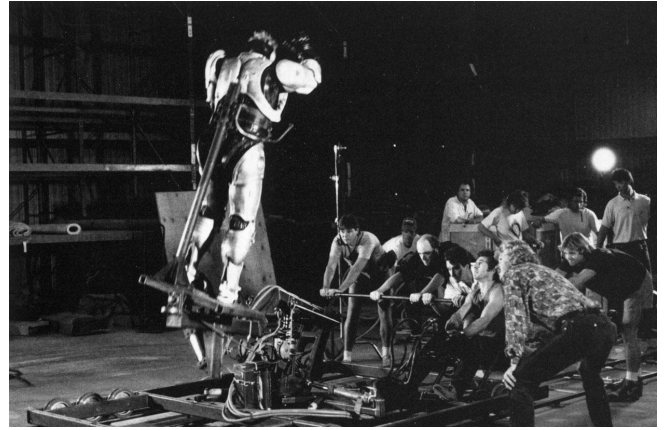


At a ceremony marking the public unveiling of RoboCop 2, the crazed cyborg goes on a mad rampage that only the original RoboCop has a chance of stopping. A pitched battle rages from the rooftop to the basement of the towering Civic Centrum building and then out onto the street. For scenes in which RoboCop clings to his adversary's back, closeups and plate material were obtained through the use of a mechanical bucking device engineered by Michael Steffe.

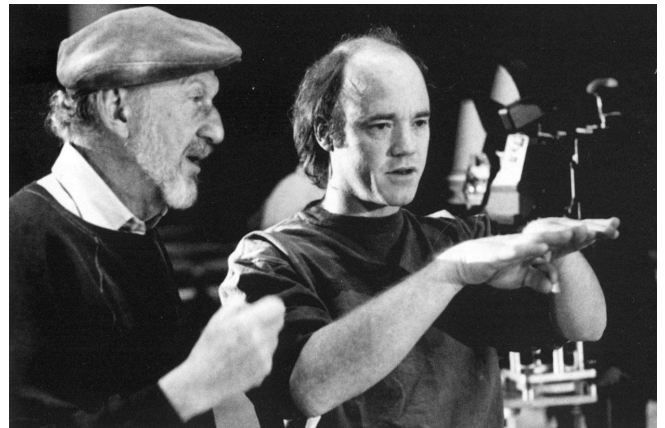
Because the title character's design had been a top priority well before the script was completed, Tippet and Davies had the difficult task of developing the creature without a clear idea of what it would be required to do. "All I knew at the beginning was that there was going to be a big battle at the end of the film between RoboCop and RoboCop 2," Tippet recalled. "Craig began developing the robot with the idea that it was something RoboCop would stand little chance of beating — a giant that could vary its height by way of gears and hydraulic rams. Jon told us to come up with the neatest thing we could. But it was difficult, because at that point there was really no framework."

Guided only by the vague instruction to 'make it neat,' Davies began drawing sketches of the possible forms the Cain monster might take. "We went with the philosophy that monsters exist primarily in your mind," explained Davies, "that if you see something and get a chance to digest it visually, it is not scary anymore. So we tried to put a bunch of stuff on this monster to kind of overload your brain, so that there was no way you could really assimilate it all. You would never have a chance to get a fix on it because it was packed with so much." Davies' first ideas contrasted sharply with the anthropomorphic look of the original RoboCop. "I wanted to do something that was more animal than human — like a Brahma bull combined with a locomotive. We went through a lot of animal shapes. But Tim Hunter — who was still on the film as director at that point — thought it should have more of a human appearance, because human beings are the biggest monsters of them all. That was his thinking and I think he was right."

With Hunter's edict to humanize the look of the monster, Davies took a new approach in its design. "We came up with something that was upright and looked basically like a man. It had four to six arms, different types of tooling — the kind of thing you see in a lot of machinery. I wanted to show that this thing was capable of self-repair, something like a guerrilla Swiss army knife. The helmet design was just a conglomeration of a lot of things. From the front, it looks like an atomic bomb mushroom cloud; but it has the profile of a sort of stylized American eagle. And then the waist is very tiny — wasplike — so the overall impression is of a stylized bodybuilder. This robot is like a big, thick-headed American male asshole — the worst, most



Depending on the shot, either Peter Weller or his stuntman would be strapped onto the rig — which could be configured in a variety of ways — and pneumatic rams would then be activated to thrust the platform about vigorously on several different axes.



Irvin Kershner is briefed on the set by Phil Tippet who supervised the photography of more than a hundred background plates.

offensive thing you could ever have angry at you. From some angles, though, it looks like a medieval knight, which was a conscious satirical comment — it's medieval technology, showing that America is not in the forefront of this kind of stuff anymore."

Working from his own drawings, Craig Davies constructed a foot-tall wooden mockup of the Cain monster. The sixth-scale rendition showed the many joints that Davies had incorporated into the design — joints that would enable the animators to vary the puppet's height. "It had what seemed like a million joints on it," said Davies, "which allowed it to expand and contract. Tom St. Amand took the wooden mockup and made blueprints from it, modifying it along the way to make it armature-worthy. Then he made up the armature — mostly out of aircraft aluminum, although there was also some stainless steel on it. Tom put a great deal of effort into figuring out the best materials to use for this thing; and because he did such a fine job with it, we ultimately left much of the armature exposed on the puppet." Four people — Paula Lucchesi, Spencer Owyang, Marc Ribaud and Merrick Cheney — were involved in sculpting the outer form which was then cast in urethane. Small plastic pieces were fabricated by the model shop for detailing. "We didn't want to use glue on anything, since glued parts tend to pop off at inopportune times during animation. So we bolted every part on with tiny brass and stainless steel screws."

The puppets were also equipped with small halogen lamps. "Because Kershner wanted the Cain monster to be seen as little as possible in the beginning," said Tippett, "he was shot without a lot of lights on location. So we gave the monster his own searchlights, and those lights were able to interact with the atmosphere to create beam effects."

"I built sixteen miniature focal spot lamps and mounted them on the puppets," Davies elaborated. "It was a good effect for the look of the monster, but the animators had a lot of trouble dealing with the electric wires trailing off of their puppets and keeping track of voltage levels all the time." Eight fully articulated, foot-tall stop-motion puppets were ultimately built to accommodate the eight separate animation units that needed to be shooting simultaneously to meet the tight schedule. In addition, four stunt versions were constructed. "The stunt puppets were cast off of the original ones in a semiflexible urethane — a basically indestructible material. They were used for all the high-speed, abusive shots so that we wouldn't have to take the chance of destroying a darn-hard-to-make model."

While on location in Houston, Tippett had supervised the shooting of more than a hundred Vistavision plates — both for Hob's hideout and for other stop-motion sequences. "It was pretty much a foregone conclusion that it would be ideal to shoot on a larger format. It was the same thing we did on the first RoboCop — shooting on a larger format to help with grain problems and improve the general quality of the image. We had a problem, though, getting exactly what we wanted in any one location. So we ended up shooting backgrounds all over the San Francisco skyline as well. We made them into four-by-five photographs which we cut up so we could truncate the perspective. We literally cut these photographs apart and glued them back together and did extensive matte painting over them."

A simplified go-motion process was used to shoot the puppets for the Hob's hideout sequence. "It was computerized rod puppetry," Tippett commented, "shooting full miniature shots or, in

some cases, full miniatures and projections combined. The system was designed and built by Pete Kozachik. It runs on a track that is twenty-two feet long. It has forward and reverse movement, as well as a camera boom for up, down, panning and tilting.” The puppet was mounted on go-motion rods that projected into a miniature hideout set which Tippett’s crew had constructed. “The set itself was built inside a small smoke chamber so that we could control the amount of smoke very carefully — an important consideration when you are dealing with stop-motion animation. We built two miniature smoke sets — one was a smoke chamber that was about twelve feet deep by twelve feet wide, with a window chopped out of it so that we could project the Vistavision background through the window and into the chamber. Then we had another which was a small four-by-four-foot box with holes cut into it. We could put our arms through the holes with rubber gloves that wouldn’t allow the atmosphere to breathe out or in.”



At the height of the battle, RoboCop leaps onto his nine-foot-tall opponent from the top of a television remote van. In preparation for the shot, boxes and cushions were placed on the pavement to break the stuntman’s fall. Also, reference footage was taken with a large cutout of RoboCop 2 erected in the frame to assist the stop-motion animators in determining proper scale.



The rear projection plate as photographed on the set.

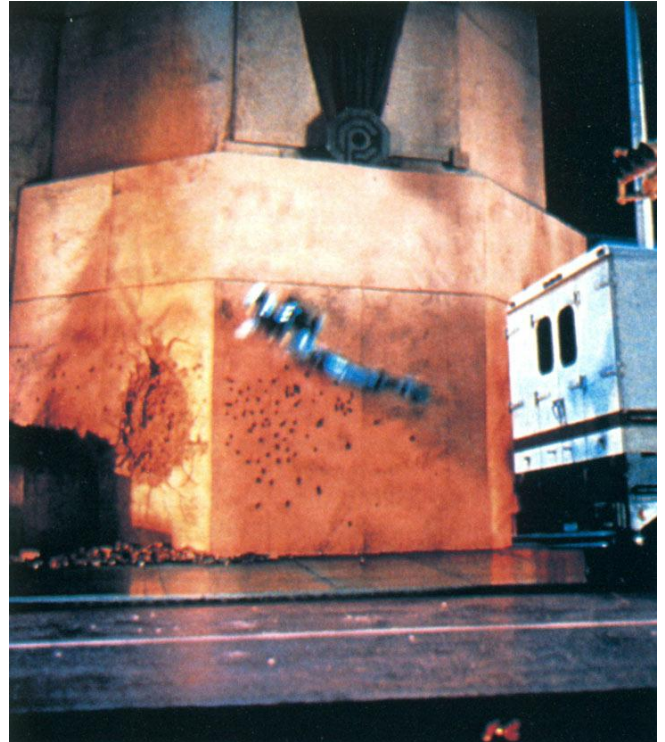


At the point where RoboCop needed to pass behind RoboCop 2, a matte was inserted that blocked out the background and the boxes.

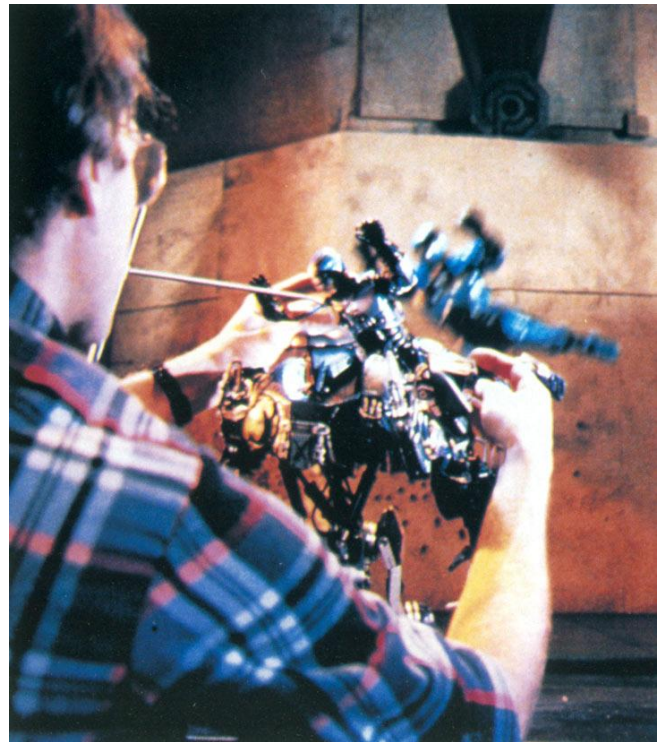
The stop-motion crew also animated the weaponry attached to the monster's various tooling arms — most notably its gatling gun, a six-barrel rotary cannon that afforded RoboCop 2 the firepower of a one-man SWAT team. Approximately half of the gatling gun shots were animated by hand. "Steve Raschke and Pete Kozachik developed a method of backwinding the camera for every frame," explained Tippett. "We blacked out the set and put in special flashbulbs with various diffusion filters over them. We'd shoot a frame, then expose another pass on top of the previous frame to produce the effect of a flickering gun. Also, Craig had designed a little gear that allowed the gun to spin in real time. So we would very carefully move this tiny gear and the gatling gun would spin, giving us a blur."

Having gunned down nearly every person in the hideout within minutes, RoboCop 2 encounters Angie — Cain's former moll who has betrayed him. A ten-inch Angie puppet was built for shots of the monster picking up the woman in one of his 'claws' and breaking her neck. "It was used in one or two shots," said Tippett. "We got lots of reference photographs of the actress so that we could duplicate her costume and hair exactly — all of which was done by Paula Lucchesi."

The mayor manages to escape his cyborg assassin, but encounters him again when RoboCop 2 makes his official debut at a press conference called by OCP at their architectural gift to the city — the Civic Centrum. The sequence opens on the plaza outside the towering edifice where Leeza Gibbons is reporting on the media event about to take place within. Since the actual building used on location was only a few stories tall, the opening shot proved to be a challenging one for matte painter Rocco Gioffre. "It required a camera move — a tilt-down from the top of the building to the reporter in the foreground. The Vistavision footage of Leeza Gibbons was locked off and rear-projected up on a two-and-a-half-foot screen. The



The matted area was then replaced with footage of the same setup — minus the boxes — to produce the final plate image in which RoboCop leaps from the truck and disappears at the matte line.

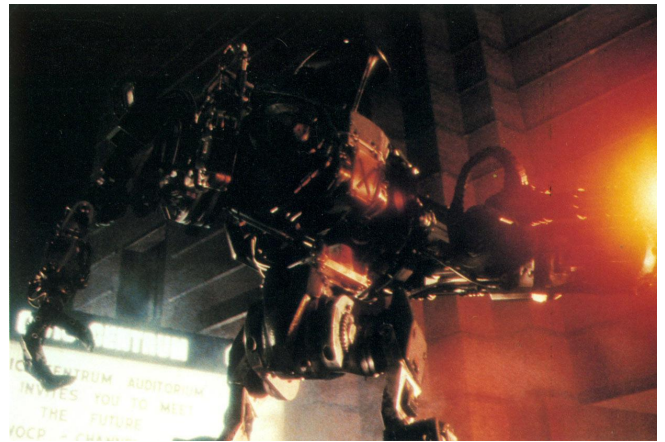


At precisely the right frame, animator Harry Walton substitutes a puppet RoboCop for the live-action character so that it can interact directly with the stop-motion RoboCop 2.

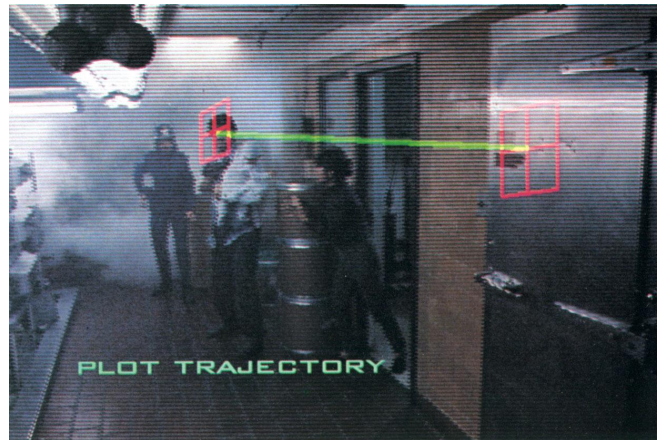
matte painting of the building was about five or six feet tall and was positioned above the projection screen — it was about seven feet from the top of the painting to the bottom of the rear-projected image.”

Once positioned, the painting was lit and shot on the same path as the rear screen projection. The stop-motion move was accomplished by matte cameraman Mark Sullivan. “It would have been nice to have a motion control setup for that,” admitted Gioffre, “but I didn’t have one available at the time. So Mark did it by manually computing increments, using a gunsight on the pan-and-tilt head of the camera. He had an arc drawn out off-camera — on the right-hand side of the painting — and then he lined up the gunsight crosshairs to that and viewed through the sight while he was doing the tilt-down. He’d fire a frame and then advance to the next position. It was about a two- or three-second exposure, so he could actually do a gradual blur by just moving the handles on the pan-and-tilt head while he was viewing. We shot it with a standard 35mm Mitchell camera, going from rear-projected Vistavision back down to four-perf.

“Once we tilted down on the Civic Centrum and got onto Leeza, we were completely off of the matte painting. We had to follow her as she walked toward camera, keeping the actual live-action building in focus throughout the shot. The camera assistant on location timed a focus pull so the background building went out of focus and they just kept on her. It was a difficult shot to pull off, making sure that we were down and on that part of the live-action by the time the focus-pull came. We got counts from the editors so that we could time the move coming off the building and onto her.” A beam of light was also incorporated into the matte shot. “We created a blue beacon sweeping by the front of the building as we did the tilt-down — like a searchlight. That was done with a small piece of steel rod placed on a rotating unit, set really close to the camera lens. A small lightbulb was glued to it and positioned out of frame. That lightbulb illuminated the rod — and



RoboCop 2 opens fire on both adversaries and innocent bystanders in front of the Civic Centrum. Weapons flashes were inserted during the stop-motion process by backwinding the designated frame after its initial exposure, then blackening the set and inserting special flashbulbs with diffusion filters for a second exposure. Phil Tippett had eight animation crews working overtime to complete the massive stop-motion assignment



RoboCop plots a ricochet gunshot that will kill a desperate drug dealer without harming the infant he is holding hostage. Peter Kuran of Visual Concept Engineering produced the ‘robovision’ effects by compositing computer generated graphics and simulated video scan lines over point-of-view film footage.

because the rod was so close to the lens, it had an out-of-focus transparency about it that made it look like a real beam of light.”

Inside the building, the press conference culminates with the dramatic unveiling of RoboCop 2, who rises from a pit in the floor up through a parting architectural model of OCP’s vision of the new Detroit. This grand entrance was achieved by using a combination of rear-screen stop-motion and motion control. “The technique we used is a derivation of the Dynamation technique that Ray Harryhausen has used for years,” said Tippett. “We plotted the foreground elements of the miniature city rising up. Pete Kozachik set up the motion control photography, lifted that shot and plotted it so that the model foreground city moved in the same trajectory and at the same speed as the background that we had shot in Texas. We had set up a little target on location that Pete could use as a reference point from which to gauge the scene of the foreground elements.”

After the shot was plotted, a stationary rear process screen was set up. “Basically, rear-screen photography is very much like shooting on an enlarged optical printer — any of the movements that have to take place with the models have to be done relative to the image on the rear screen. So what you see in reality as you’re looking at the setup is the static background which has a photographic image on it and a foreground piece with the model in it that is programmed to mimic or duplicate whatever action is going on in the background. In essence, the entire stage is turning and panning back a little bit until the robot comes up from the bottom of the pit.” The monster’s actual ascent from the pit was photographed on a motion control set equipped with a mechanism that pushed the robot up from a hole in the floor. The miniature New Detroit — built by the model department — was hinged and pulled apart by a cable attached to a small stepper motor.

Predictably, disaster strikes the press conference as RoboCop 2 rages out of control. An attempt by Dr. Faxx to shut him down by remote control fails when the robot grabs the controller out of her hand and destroys it. The action was a combination of stop-motion animation and live-action. “The controller was wired to a broomstick with a piece of monofilament and then yanked out of Belinda Bauer’s hand,” explained Tippett. “Then we skipped a few frames and made a substitution with the miniature controller later on. When we yanked the controller out of her hand, the controller itself turned into a blur on the film. So we just made sure that the robot’s hand was positioned ninety percent over that blur and substituted the real controller for the little miniature one.”

RoboCop arrives to engage in a last showdown with the mechanized monster. For closeup shots of the monster interacting with actor Peter Weller, a full-scale head and torso version of RoboCop 2 was utilized. “It was eight to nine feet tall,” recalled Davies, “depending on the arrangement of the mounting, and it weighed almost eight hundred pounds. We vacuformed it out of styrene. The skeleton was made of cold rolled steel to make it very strong, and other sections were made of aluminum or plastic. It had six miniature halogen lamps on it, but four of those were taken off for most of the scenes. It was fully articulate — every arm, shoulder, wrist and claw could be positioned however we wanted. Also, all of the joints could be loosened up so that it could be puppeteered remotely. The puppeteering itself was pretty crude — basically the operators held long poles that were screwed into specific areas and just moved things around

like that. They wore black outfits and the poles were painted flat black, as well. The operators wore crash helmets because this thing was so heavy — if it had fallen and hit them, it would have been very serious. We had a three-person puppeteering crew — Lisa Sturz, Gregory Ballora and Jay Davis — and it was just a simple, push-pull kind of thing.”

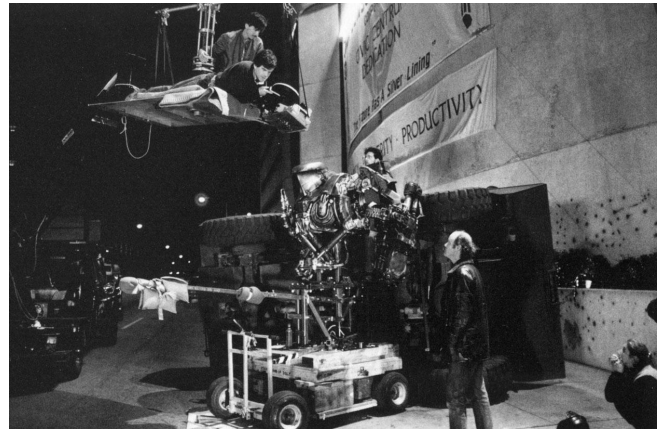
The one-on-one battle between RoboCop and the Cain monster is a showcase of stop-motion animation played out from the roof to the basement of the Civic Centrum. As Cain follows his adversary into an elevator shaft, the two are catapulted to the roof of the building — a set designed and built by Davies and the stop-motion crew. “It was kind of funny,” commented Davies, “because the production actually wound up building the full-size elevator shaft from pictures of our models — just the opposite of how it usually happens. It was good for us because we were able to design the set to meet all of our stop-motion requirements, which was much easier than having to duplicate an existing set and then work within that.”

“We built a horizontal miniature elevator shaft that was twenty feet long and made of plywood,” Tippetts elaborated. “Every two feet or so was a separate trapdoor that had been engineered to lock with clamps so that the animator could open the door and close it in between frames and move along with the Cain puppet as it was either falling down the wall or climbing up. There was a little black slot that ran the entire length of the set, and the rod that held the puppet extended through that slot and attached to our motion control track so we could blur the puppets as much as possible. So the major forward movements and some side-to-side movements were done motion control; but the movements of the puppets themselves, the arms and the heads, were done by hand with regular stop-motion. We worked on the elevator shaft sequence for about a month. Eric Leighton was the animator in charge of that sequence, and Pete Kozachik and Cameron Noble were the cameramen.”

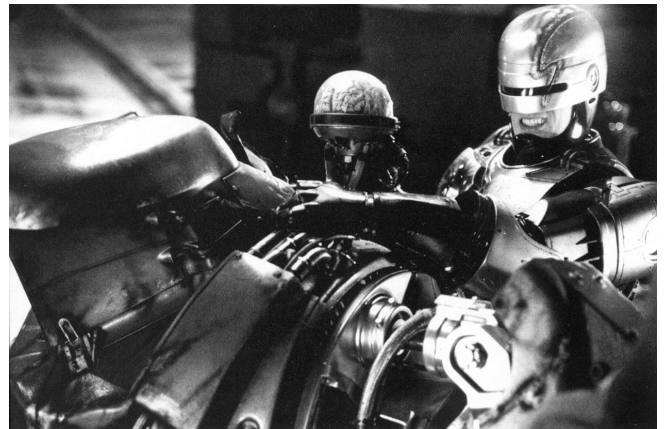
The shot of RoboCop and the Cain monster rocketing up through the elevator shaft and bursting through the skylight on the roof of the building was filmed on a high-speed set. “Bart Trickel designed an amazing launching mortar that had huge springs in it to propel the two puppets,” Tippetts revealed. “They blasted through a roof section we had built that was about twenty-by-ten feet. The skylight was made of real glass that we got from a biological supply house. It was the kind used for microscope slides — you breathe on it and it shatters. That sequence also had three or four cuts of the Cain puppet coming up toward RoboCop. Eric Leighton spent fifteen or sixteen hours animating that. The puppet was hooked up to the motion control track and then he was physically hand-animated, moving his arms and legs to propel himself up the track.”

On the rooftop, Cain dangles RoboCop over the side. Determined to take the monster down with him, RoboCop pushes off of the side of the building and the two cyborgs plunge one hundred fifty stories down and through the street into the basement of the Civic Centrum. “At first,” said Tippetts, “the shot of Cain and RoboCop hanging from the roof didn’t look as high up as Kershner and Davison wanted it to. So we cut the background photographs and shrunk the streets down so it appeared that these things were converging toward much more of an incident perspective. Then we blew up sections of the building and duplicated them and pasted them over themselves to create a feeling of even more height. The photographs were mounted on gatorboard, which allowed us to go back in from the side and add little twinkling lights or miniature cars going down the street. Also, on location we had shot about fifty people in the

street, running from Cain. We projected that into the flat art to show the reaction of the crowd below.” As the robots fall, an overhead shot reveals a steep canyon of buildings. “My worst fears came true in that shot, because it is pretty obvious that you are looking at stop-motion models. Making things fall is always the toughest stuff to do, and I was not able to devote the time and effort needed to work out all the problems on that.”



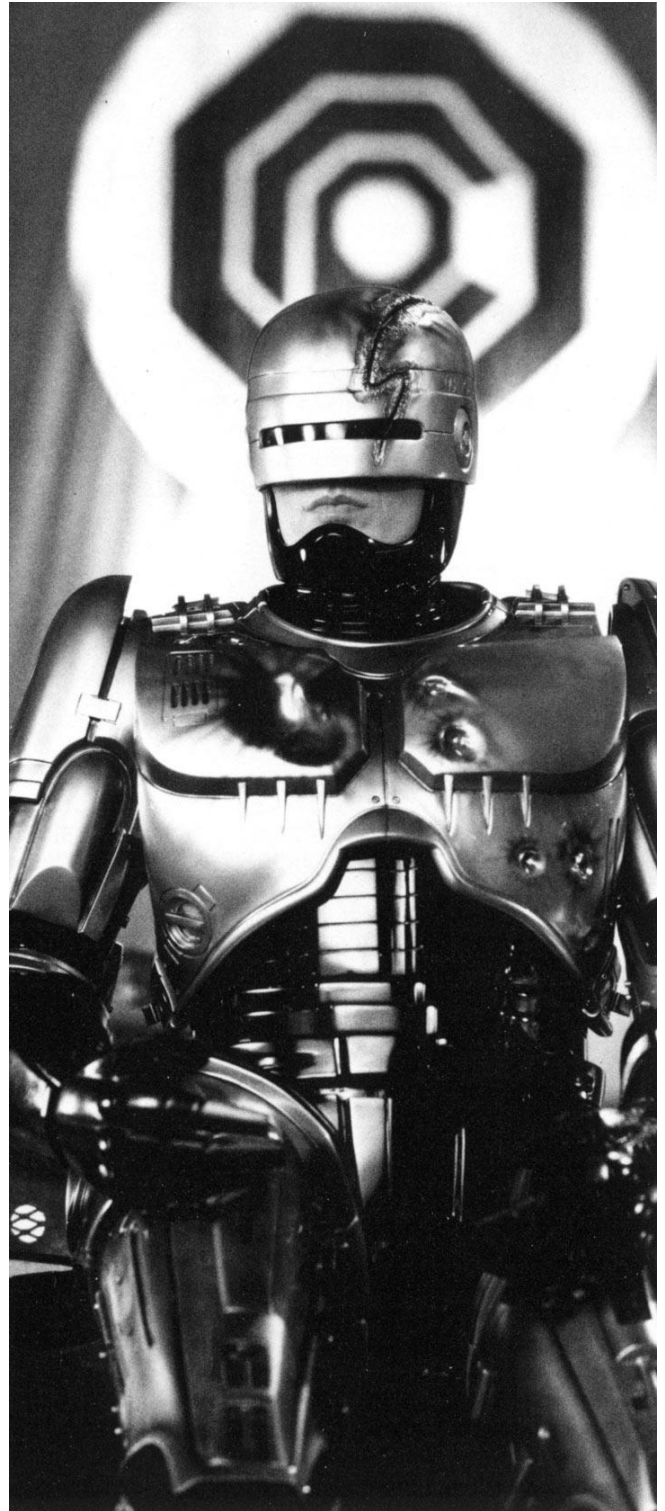
On location in Houston, Phil Tippett provides direction to plate photographer Rick Fichter who is suspended from a crane over the articulated RoboCop 2 torso and the armored personnel carrier it has overturned. Vistavision was employed for all plate material to provide an optimal quality rear projection image.



RoboCop finally destroys the murderous RoboCop 2 by penetrating its armor and ripping out the psychopathic brain that empowers it.

The falling sequence also required an extensive forced perspective miniature of the Civic Centrum exterior. “As they fall, they crash through an overpass and then through the street — that was a full miniature. It was a very tricky, literal duplication of an underpass that existed on location. To duplicate it exactly, the miniature would have wound up being something like one hundred feet long. Since we didn’t have the capability to build or light something that big, we elected to make the set with a quickly diminishing perspective. So it was usable only from one point of view. It was about fifteen by ten feet, made of wood and plastic. Because twenty-some takes were required for the fall, several stunt versions of the RoboCop and Cain monster puppets were employed.

Incredibly, both cyborgs survive the fall. The battle continues in the basement of the Civic Centrum as the Cain monster picks up RoboCop and slams him against the basement pipes. An eight-by-ten-foot square miniature basement set was built to accommodate the action. After RoboCop escapes his opponent’s hold, the monster crashes up from the basement to the street where an army of police join the effort to contain him. Intent on helping her partner, Ann Lewis boards an armored personnel carrier and rams it into the Cain monster, crushing and pinning him against a wall. For a moment, he is still — but pandemonium ensues again as the monster recovers and dumps the vehicle over on its side. A sixth-scale model was built for the scene. “The armored personnel carrier was about three feet long and was made out of various laminates of plexiglass,” Tippet explained. “It was constructed by Spencer Owyang and made to function as a high-speed prop for the shot where Cain gets rammed into the wall. It also functioned as a stop-motion prop. The shot was cropped in such a way that we were able to simply weld a metal rod to the vehicle and push it into a miniature wall, which was composed of various collapsible materials. We put our standard miniature Cain between the wall and the APC, and just ground it into the wall until we



Only slightly the worse for wear after the battle, RoboCop stands ready to serve the public trust, protect the innocent and uphold the law.

got the eighteen frames we needed. The Cain puppet was our hard urethane version — basically our stunt puppet.”

Having distracted the monster with a supply of Nuke, RoboCop jumps onto his back so that he can reach the cyborg’s brain center and disengage it. A bucking rig was devised by engineer Michael Steffe for live-action cuts of RoboCop being flailed around on the back of his adversary. “It was a horrendous device that we would strap the stuntman onto,” noted Tippet. “In some cases, we would even use Peter Weller. The rig was about twelve-by-ten-feet wide — on dolly tracks — and operated by opening or closing valves that actuated pneumatic rams. It was made of steel and run with compressed air. The rams would lift the character up in the air about four or five feet and bring him down quickly and then traverse him from left to right in a matter of milliseconds. It was a hell of a thing to watch a body being slammed around in it. I broke a rib on the stupid thing. I was a stand-in for one of the shots and the rig lurched sideways — the tiniest little lurch, but enough to crack one of my ribs.”

Clinging to his adversary’s back, RoboCop finally manages to penetrate the chamber holding the organic remains of Cain’s drug-crazed brain and rips it out, smashing it onto the pavement. The lobotomized monster falls to the ground, a heap of mindless metal. His demise marked the end of one of the most strenuous stop-motion efforts Phil Tippet had ever orchestrated — a feat made more remarkable by a schedule that was lamentably brief. Eight separate animation units had worked virtually around the clock for nearly four months to complete the project. Not only was the schedule a challenge, the nature of the puppet itself proved to be difficult. “It was a strange puppet to photograph,” said Tippet, “because there were very few angles that really showed it off well. The head, for example, looked very different depending on whether you were looking at it straight on or from a low angle. Also, we wanted to do more than just bland, robot-type movements. So we tried to give him gestures and poses that would help to create an actual character. But there was so little time — the production schedule was just ridiculous. We found ourselves sometimes working a seventy-two-hour day — working with a second unit at night and the first unit during the day.”

Though the whole affair of RoboCop 2 is a public relations disaster for Omni Consumer Products, its chairman of the board drives away at the end — confident that he will be exonerated and already plotting his company’s next strategy in gaining corporate control of Detroit.

With the film ending on such a note, it should come as no surprise that a third installment in the RoboCop saga is already in the works — despite the fact that RoboCop 2 failed to meet the boxoffice success of its predecessor. The lackluster showing was a disappointment for producer Jon Davison. “I’m sorry that more people didn’t like the picture. By the time you are finished with the whole moviemaking process, it is impossible to be objective. Maybe twenty years from now I will be able to run the film and analyze it objectively. You work so hard on these things and you just hope that people like them — and when they don’t, it’s really depressing. The whole thing was ass-backwards, because the studio came up with a release date before they even had a story. It was like, ‘We’re opening in two thousand theaters, kid, and you better put something out on the screen on such and such a date.’ As soon as that happens, the whole thing has gone to hell in a handbasket.”

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MAXIMUM IMPACT

article by

Mark Cotta Vaz



The top boxoffice hits of the summer of 1990 were fantastic dreams brought to life on the silver screen — the supernatural fantasy of *Ghost*, the Martian landscape of *Total Recall*, the Sunday comic page palette of *Dick Tracy*, the time travel effects of *Back to the Future III*. But *Die Hard 2* arguably topped the list in harnessing the power of physical and visual effects to meet its story demands. Not only was the universal playbook of the effects masters' art brought to bear, but some new chapters were written during the production.

The latest installment in the adventures of New York City detective John McClane (Bruce Willis) continued the storytelling philosophy of 'exaggerated reality' set by producer Joel Silver in the first *Die Hard*. "Even though a movie like *Die Hard 2* is bigger than life and sort of James Bondian, you have to create the maximum impact from a realistic premise," explained director Renny Harlin who was pegged to helm the production in recognition of his work on *Nightmare on Elm Street 4* and *The Adventures of Ford Fairlane*. "It has to be shot so it feels real. It's an exciting challenge." The maximum impact style of *Die Hard 2* was dictated by the personality of John McClane, a hard luck hero with a habit of taking on impossible odds. "John McClane is a blue collar kind of character everybody in the audience can relate to. He's not a superhero; he doesn't wear hip clothing or look great; he's sort of worn out and tired and maybe a little pissed off. Everything is not perfect in his life. But he has a moral code and a sense of responsibility I guess every one of us would like to have. If there's a situation where the authorities are not doing anything — or aren't doing a good enough job — he feels that he has to get involved and do the right thing."

In the first *Die Hard*, a Christmas season visit with Holly (Bonnie Bedelia), his estranged wife in Los Angeles, turned into a battle to the death with terrorists inside a high-tech skyscraper. For the second film, McClane would face an even sterner test — rescue Washington D.C.'s Dulles International Airport from Colonel Stuart (William Sadler), a renegade U.S. military officer whose men capture the airport during another stormy Christmas in order to liberate General Ramon Esperanza (Franco Nero), a Central American military comrade being flown to Dulles under extradition for drug charges. Stuart and his men secretly commandeer a church on the

outskirts of the airfield and transform it into a command post from which they shut down the runway lights and cut off communications between the control tower and all incoming planes. The night and blizzard conditions make it impossible for the planes — including an L-1011 bearing Holly McClane — to land safely, forcing the unsuspecting pilots to circle above, their fuel supplies dwindling.

The logistics of setting the action within an international airport posed major problems. “It was complicated dealing with the airports,” said Harlin. “Some of them didn’t want to get involved. They thought the movie would make them look bad. But even though LAX (Los Angeles International Airport), for one, tried to cooperate with us, there are a lot of FAA (Federal Aviation Administration) safety regulations. You can’t, for instance, film using weapons inside an airport.”

The main effects challenge on the film would be creating the stormy nighttime airspace crowded with jets as well as the fiery destruction of three aircraft. “A pivotal story point,” said visual effects supervisor Michael McAlister of Industrial Light and Magic, “was that a flock of passenger jets had to be stranded above the storm clouds due to the commotion taking place on the ground. It was imperative that the audience believe that real jets were in jeopardy. Since the stormy weather conditions called for in the script are not conducive to flying, Joel Silver and Renny Harlin realized right away that shooting these scenes with practical air-to-air photography was out of the question. At a rate of \$60,000 to \$75,000 per day to rent a passenger jet — not including fuel — it would have taken no time at all to break the bank trying to get the correct weather and lighting conditions to shoot. It’s difficult enough to shoot air-to-air when all you have to do is get the camera and subject aircraft positioned correctly. Add the complicated choreography of jets, clouds and action called for in the script, and there was only one alternative — call in a miniatures unit.” Awarded the Die Hard project after a protracted six weeks of negotiations, ILM had only five months to complete nearly forty major effects shots.

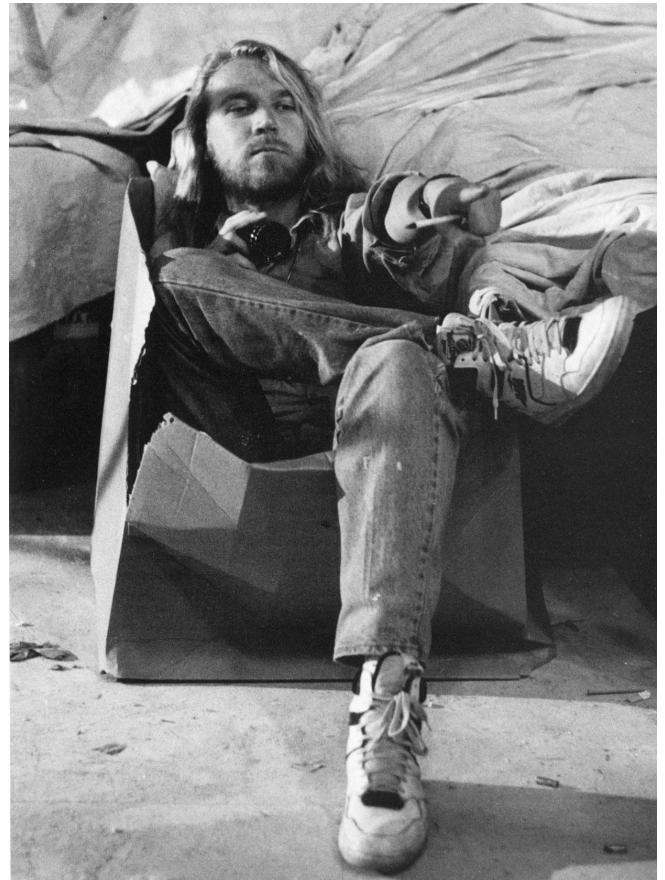
Before the actual effects shooting could commence, scale model airplanes had to be built — and time got tight during the long period of research and design. Although there would be no practical air-to-air filming, real planes were still needed for a variety of shots, mostly establishing shots and scenes where aircraft would taxi down runways. Until the required planes were secured, modelmaking was on hold. Included among the practical aircraft were Holly McClane’s L-1011, a C-130 military transport that would be ferrying Esperanza and a 747 that would figure in the terrorist’s final escape attempt. “In the case of the 747,” said Charlie Bailey, who cosupervised the model work with Jeff Olson, “we eventually had to build a 747 cargo plane because the production couldn’t rent a passenger plane for the live shots. Essentially the 747 cargo plane is the same as the passenger model except that it has no windows.”

The turboprop plane that would be transporting Esperanza to Dulles developed as a curious mix of designs. “The military transport craft in the film is actually a cross between a C-130 and a C-123,” noted McAlister. “Everybody wanted to use a C-130, because it’s the military’s state-of-the-art workhorse plane. The problem was none were available that could be rented for a movie. What the production did was rent a C-123, which is the predecessor to the C-130 but is propeller driven and not quite as big or fierce looking. Then they modified it to look like a C-130

by hanging phony jet engines off each wing. The problem is that when you hang things off an aircraft's wings, you destroy the aerodynamics so that the plane is no longer airworthy. Therefore, the production was limited to practical shots of the modified C-130 when it wasn't actually flying, such as taxiing down a runway. All the airborne shots required a miniature."

During the model design phase, McAlister and visual effects art director Paul Huston — working with production designer John Vallone — came up with not only the scale required for each model, but also aircraft paint schemes and corporate logos. "It took a long time to decide what the paint jobs and corporate logos were going to be," said Huston. "Everything had to be checked out to make sure the designs weren't infringing on existing airlines that might sue the production for suggesting their planes were involved in this kind of activity."

By the time the design phase was completed in January 1990, the model list included a mix of military and commercial aircraft — one F-4 Phantom jet, one modified C-130, one 727, three 747s, five DC-8s and two L-1011s. The scales ranged from the huge 747 models — which were approximately twenty-three feet long and forty inches high from belly to cockpit — to the F-4 with its six-foot fuselage and four-foot wingspan. Because of the extended design phase, the modelmakers had only two months to build the planes and ready them for shooting. "Going in, I knew the schedule was going to be a horror story given the number and size of the planes we had to build," Bailey recalled. "We had to design the models with access panels for the pyro rigging, as well as interior wiring for radio-controlled lights, and build a bridge truss through the length of the interior to make sure it was rigid enough and wouldn't buckle. The models were standard fiberglass and aluminum, but there was a lot of weight and mass to them. The scale was so huge that if you took one of the 747s and put on big enough wings, you could seat three or four people in it and fly it. To meet the deadline, we had to have about thirty people working on the models over the course of the two months. I pulled in Mike Fulmer, who was on sabbatical, and essentially the same model crew that had worked together on *Always*. We had outside contractors build the DC-8s and 747s — which came to us unfinished — and then we did the paint jobs,



At the helm of what was reportedly the most expensive movie ever made, director Renny Harlin chooses an unusual vantage point from which to line up a shot for *Die Hard 2*. In his second action-packed film outing, detective John McClane battles an elite force of military extremists who have seized control of Dulles International Airport and crashed a fully-loaded passenger jet as a warning to officials not to interfere with their plans to liberate a Latin American comrade under indictment for drug trafficking. Effects for the megahit film were overseen by special effects coordinator Al Di Sarro and visual effects supervisor Michael McAlister of Industrial Light and Magic.

interior wiring and put on landing gear and workable flaps. The big planes required so much paint that I hired Tim Greenwood, an expert car painter, and set up essentially an automotive paint shop for the models.”

Since the story called for planes to fly through storm clouds, bluescreen techniques were impossible as any smoke effect would contaminate the blue. Instead, McAlister envisioned a live-action-style shoot with models flying above and through clouds of smoke. The approach required an outdoor location with predictable, and plentiful, winds to propel the smoke — fans alone would not be able to move the masses of smoke needed to simulate a winter blizzard. The location would also need a simulated airstrip and plenty of space in which to stage the explosive crash of several planes.

The site selected was a remote airstrip in the Mojave Desert — a seemingly unlikely spot for simulating jets flying through a wintry blizzard. But the Mojave Airstrip had the necessary winds, which roared westerly through the Tehachapi Pass and into the valley with force enough to keep thousands of electricity generating wind turbines whirling on the mountainsides. The isolation and sparsity of air traffic was also ideal — airstrip management was easily persuaded to rent out one of the main taxiways for the shoot. During close to a month of location work, McAlister would see only four airplanes land at the site. Early in March, nearly sixty members of ‘Crash and Burn Productions’ — the tongue-in-cheek nickname adopted by the effects team — and several forty-foot trailer trucks full of equipment and models convoyed south from balmy Marin County to the windswept Mojave Desert valley.

Although the brunt of the visual effects work would be done as second-unit-style miniatures, it was decided that several model shots would best be accomplished against bluescreen — specifically, the first appearance of Holly’s L-1011 and Esperanza’s C-123/130 escorted by two F-4 Phantom jets flying above the clouds, bound for Dulles at twilight. “What I like most about effects,” observed McAlister, “is tricking the audience into thinking they’re seeing something they’re really not — in this case three composite shots that look like real air-to-air photography. These shots would have been too expensive and too difficult to get shooting air-to-air. It was tough enough for us just to go up and find the perfect weather conditions for a beautiful orange sunset without having to fool around positioning several aircraft. As it was, we made two separate attempts, filming out the side window of a Lear jet, before we finally photographed a background that was acceptable. These bluescreen composites were difficult because the balance of lighting, color, sharpness and density of the aircraft needed to be perfect to prevent the audience from subconsciously knowing that the shots were fake. The light from the setting sun needed to play off the shiny surfaces of the jets at just the right angles. The jets needed a soft, diffused look to tie them into the hazy sky, yet they needed to retain enough detail and density so you could see clearly what they were.”

“The goal was to make everything look absolutely real,” said optical supervisor Stuart Robertson. “Working with things that are supposed to be real has a certain advantage — you know what can and cannot be. The challenge for the bluescreen work was to match the high quality of the live work. When we composited the military escort planes, we had to juggle with the exposure and the transparency of the matte to get the sense of a plane pulling out of the clouds. The challenge to Peter Daulton, our stage photographer shooting the bluescreen, was to

get a shot that would both create a matte we could work with and provide a lighting setup we could play with throughout the scene. When Peter shot the models, he made not only one pass on the plane itself, but also three or four additional passes — one maybe highlighting from the top, another highlighting from the side, so we would have a mix of lighting that we could apply to the plane as it would move through the scene. In the shot, as the first plane peels off, we're actually fading the plane out of its holdback matte. It's just a double exposure, giving a sense of movement through space."

While ILM set up shop in the Mojave desert, Renny Harlin was busy with the first unit location shooting. Harlin, whose usual preproduction work included storyboarding every shot and planning all the visual and special effects, was well prepared and cool under fire. "It was the first time I'd done a huge picture; but rather than putting pressure on me, I found it all very exciting and challenging. When you're working a movie that's going to cost a lot of money — and everybody knows it's going to cost a lot of money — and it has to be able to compete with the others, you get your wishes maybe a little easier." That deep pockets philosophy would be tested when the massive production journeyed to its winter weather locations and found sunshine instead of snowstorms — an omen of what would turn out to be one of the warmest winters on record. "We had arrived at Moses Lake, Washington, late in the evening, and the entire countryside was covered in snow. When I woke up in the morning, ready to go to the set, I looked out the window and there was not a single snowflake, just green grass everywhere."

Local high school kids were hired to cover acres of ground with snow blankets and trucks were employed to bring in snow from hundreds of miles away. But by the time the trucks arrived the snow they were carrying had melted down to sludge and ice cubes. To salvage the Moses Lake location, other shots were substituted; but soon the Die Hard caravan had no choice but to pack up and hit the road in search of snow. "I had told the studio that it would cost a lot of money to have snow in this movie," said Harlin, a native of Finland. "I'm from a snow country, and shooting in snow is always problematic. But for the dramatic impact of the movie we had to have it. The conditions would give McClane one more obstacle to overcome. The storm was also important because it prevented the planes from landing. We decided to just go for it."

Although plastic flakes and other snow substitutes would be used in soundstage shooting, there were ecological concerns about releasing plastic flakes into the open environment. In addition, FAA regulations forbade the use of plastic and mineral particles in the vicinity of aircraft, a problem for the production since real aircraft were required for numerous shots. It was decided that the only recourse was to produce a biodegradable flake which could simulate snowfall, be generated in massive quantities and pass every federal regulation and environmental concern. "We knew we had a problem and we knew we had to solve it some way," said special effects coordinator Al Di Sarro, a veteran of the first Die Hard. "I mean, when your producer, Joel Silver, says, 'They didn't have to leave the planet to do Star Wars,' that tells you you'd better come up with something. We called UCLA and USC, but most of the think tank process we went through was in-house."

Bob Graham of Graham Enterprises — an outside vendor specializing in design and development for film studios — was brought in by Di Sarro to crack the snow case. Faced with a dwindling one-month research deadline, Graham engaged in a bit of sleuthing and learned

probably more than he ever wanted to know about the history of soap flakes. “When I was called in to find a snow substitute, it reminded me that when I was a kid there was soap detergent in the form of flakes. It took a lot of phone calls to different companies, but I discovered that fifteen years ago the entire industry had switched from flakes to granular soap. The granules are probably easier to make — the soap comes out like a big solid bar that they can just grind. To make flakes you need special machinery for an elaborate process of heating, chilling, conveying and cutting the soap. But the advantage of using a soap flake was that we could make it using the least ingredients. The additives are what drives the environmental agencies crazy. That was part of the trick, finding the original composition for soap without all the additives. We had to go through the different compositions of the soaps out on the market to find one that had one hundred percent natural ingredients — no additives, no fragrances.”



More than a dozen large-scale model airplanes — ranging from six to twenty-three feet in length — were produced in the ILM model shop and by outside contractors. Care was taken to devise distinctive paint jobs and corporate logos that would not infringe upon those used by actual airlines. Modelmaker Joe Martinez adds detailing to the fuselage of an L-1011 passenger jet.



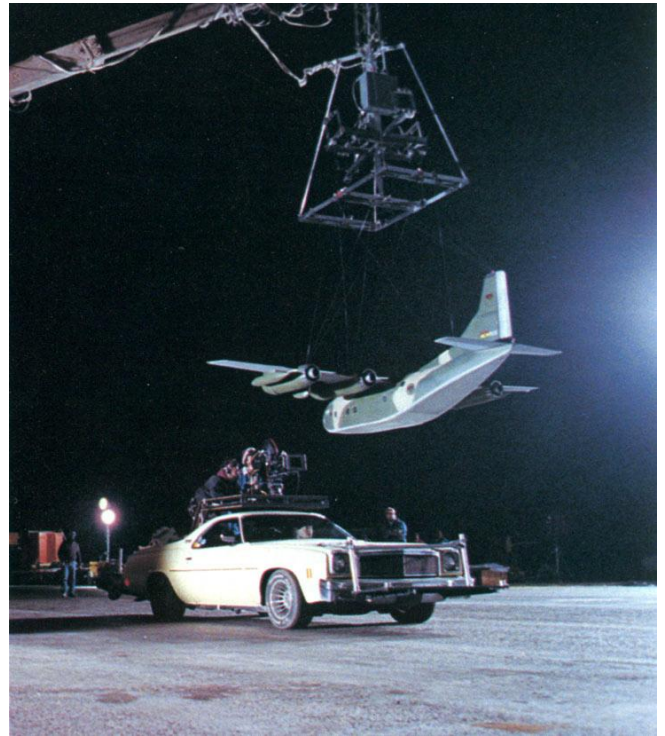
While most of the planes were commercial jetliners, the script also called for two military aircraft — including an F-4 Phantom being painted by modelmaker Kim Smith.

Graham also discovered that the basic formula for soap was not the exclusive patent of a detergent manufacturer, but centuries old, as basic a concoction as boiling goat's tallow and wood ash to make soft potash soap. "The problem with going back to the simplicity of the formula is that the soap becomes so soft that it can't be made into flakes — it turns into a kind of gum. Once you get to the purest form — where it's a biodegradable agent — you have to go through a heating and cooling process to get it to flake. To make a soap you can flake it has to come out as a film — a molten liquid that is chilled on a steel plate prior to being ground into flakes."

Before such flakes could be manufactured, an existing factory on the East Coast had to be retooled to produce soap the old-fashioned way. "There was some old machinery that this factory had basically abandoned that they were able to adapt for our purposes even though it had never been used precisely for soap flakes." A conveyance was set up to move the chilled soap film to revolving mesh screens that would chop the film into flakes. "The actual soap film was probably eight feet wide and way less than a sixteenth-of-an-inch thick. The conveyance was a continuous feed mechanism that fed the film, chilled it and ground it up nonstop. The screens used to grind the film looked like propellers. They were about eight to ten feet in diameter, maybe fourteen gauge thickness, and were mounted on frames and axles that counter-rotated. As the film dropped through the screen, it was basically cut into the desired size flake."

Meeting the delivery deadline required the enthusiasm of the factory workers and adherence to an around-the-clock production schedule. "The workers got paid for their time, obviously, but they were also excited about making a product that was going into the movie and not just disappearing into the world of soap," Graham laughed. "Once we got started actually producing the soap flakes, we ran the equipment for four weeks solid, working crews twenty-four hours a day to meet the production demands. We first produced forty thousand pounds of flakes and shipped it to Alpena, Michigan, where the production had moved for location shooting. They went through the first batch very quickly, so we made another forty thousand pounds and then another ten thousand pounds after that."

Although the falling snow problem had been solved, there was now the need for a ground snow effect. For Al Di Sarro the answer was simple — crushed ice, and plenty of it. "I had known that Union Ice had a machine that crushed ice for their own in-house facility, so we examined it and found that a three-hundred-pound block of ice that fits snugly into the crusher produced a beautiful snow effect when we ran the machine at high-speed." The logistics of putting in



On location at a small airstrip in the Mojave Desert, an ILM film crew prepares to photograph a modified C-130 military transport which is carrying General Ramon Esperanza to the United States to face drug charges.

motion multi-ton ice crushers added to the over-the-top scale of the production. One ice crusher alone was as big as a two-car trailer and needed to be towed by truck to each site. "I sent my purchasing agent ahead to each location and he lined up forty-foot refrigerated trucks filled with three-hundred-pound blocks of ice. I had six to eight of those trucks standing by, day and night, at each location. As the evening shoot progressed, we would crush the ice and empty these forty-foot trailers using hoses that sprayed the crushed ice over the set. During location shooting in Denver, we literally snowed in the whole approach and drive-in to Stapleton Airport with crushed ice. When we used the ice crushers, we would crush some two hundred thousand pounds of ice an evening to produce the ground snow effect. We would start sometimes six hours before our shooting call to prepare the set. And then, of course, it had to be maintained through the course of the night. During the shots, we were also blowing soap flakes into the air to create the illusion of a blizzard."

To assure continuity between the main unit work and the visual effects footage — a must given the vagaries of weather — Paul Huston traveled with Harlin and the first unit to each location to serve as eyes and ears for the Crash and Burn crew. "I would take still photos of the conditions," Huston reported, "but mostly I would keep my eyes open. We had gone through a lot of preparation and broken the boards down into all the scenes surrounding our shots so we could match our visual effects work to the preceding and subsequent live-action in terms of camera angles and weather conditions. I would watch how they shot their scenes and then call Mike in the morning and describe the conditions. It was important, because due to the weather problems the production was having, the first unit was only one day ahead of Mike's miniature unit and we were concerned with matching the look."

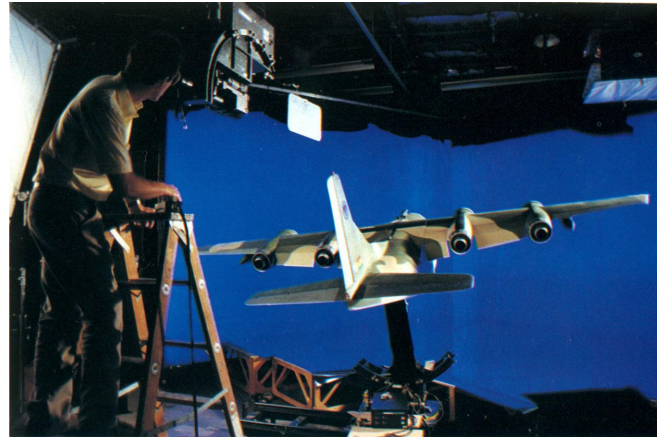
With a month to complete their effects shots, the Mojave crew was not only tested by time but by the cold and windy Mojave nights. "It was the most bizarre location work I've ever done," asserted Charlie Bailey. "The wind was incredible — giant vortices wailing down the mountain, with gritty sand blowing five or six feet off the ground at more than forty miles per hour. We all had motorcycle goggles on, all wrapped up with scarves — we looked like a bunch of World War II desert rats."

The crew — which spent its days at a hotel a half-hour drive away — erected a virtual tent city at the airstrip to house the tons of cameras, lights, models, food services and other supplies. For the flying setups, the scale models were suspended by crane ten to twenty feet above the ground, secured by wires attached to each wing as well as to the nose and tail. The wires were connected to a radio control flying rig that could be manipulated remotely to make each plane tilt, bank and yaw over the smoke clouds. "For the smoke," said McAlister, "we used several Navy foggers — the kind used to hide battleships at sea. The foggers are only about four feet long and three feet square, but they put out an incredible amount of smoke. They're basically oil vaporizers, and we used mineral oil. When the foggers heat up, you inject the oil which gets vaporized and turns into billowy clouds of white smoke. We'd produce a blanket of smoke that was probably a hundred feet wide and a quarter mile long by the time it dissipated. To lay down that much smoke, we modified a unique idea I learned from the English effects crews during the filming of Willow. Taking about a dozen six-foot sections of eight-inch galvanized air conditioning duct, we laid them end to end creating a tube about eighty feet long. We left gaps

of about four inches between the end of each pipe and the beginning of the next, and wired them securely into place. What we ended up with was a sort of flexible snake of eight-inch tubing with big holes in it at regular intervals. We put air movers at both ends to draw the smoke from the foggers and force it through the tube and out the various holes. The wind would then pick up the smoke and carry it along the ground as though it were a massive fog bank.”

The mass of smoke moving in relationship to the suspended planes created the illusion of aircraft in flight. To direct each shot, McAlister was positioned on a scissor-lift high above the ground and crowded with assistant director Ed Hirsh, director of photography and camera operator Kim Marks, camera assistant John Gazdik and radio control operators I.J. Van Perre and Jon Foreman. Cranes were not only used to suspend the models, but the lights and cameras as well. The camera was suspended from a custom boom arm built by Dick Dova which could be moved into position from ground level by unit grips. Marks was able to manipulate the remote control camera head from the lift. A video monitor provided director McAlister with a vital camera-eye view.

"The lift would raise us above the smoke," McAlister recalled, "and everything underneath — such as trucks and crew — was obliterated by the smoke. We were above the clouds — it felt like being on Mount Olympus — and we were watching the incredible realism of these airplanes flying. I think everybody on the lift knew that something good was happening, that we were making images that had never been made before. We'd shoot anywhere from four hundred to one thousand feet of film in one take when the clouds were really good. I would watch the monitor, shout directions over the radio headsets for the grips to move the camera boom left or right, up or down. I would give hand signals to I.J. about the banking position of the aircraft, cue the guys operating the smoke machines for more or less smoke. Meanwhile, Ed Hirsh would be struggling to anticipate my next cue so that everyone would be prepared to react. The entire shooting mode was very spontaneous. Kim Marks would compose and operate the shot by instinct. I would see something I liked and pursue it; Kim would see something he liked and pursue that. We got very good at this aerial ballet that we performed nightly." Winds of five to ten miles per hour proved ideal for producing the illusion of thick, rolling storm clouds. If the winds exceeded that, the smoke would be chopped into an unacceptable foggy look, while calm



Although it was determined that live-action-style photography of the model planes would best serve the film — where stormy night skies were required — a few shots were accomplished with traditional bluescreen composites. Included were three shots of the C-130 being escorted by a pair of F-4 Phantoms. Visual effects camera operator Pat Sweeney prepares for a motion control pass on the transport.



Bluescreen was also employed for a scene in which John McClane ejects himself from the cockpit of the C-130 just moments before it explodes on the ground. A special rig was devised to tumble actor Bruce Willis in an ejection seat in front of a bluescreen. With appropriate camera moves and compositing over a background explosion plate, the effect was of the character being blasted up toward the camera — ostensibly six hundred feet in the air — as the aircraft exploded beneath him.

air moved no smoke at all. “If it got really windy, we couldn’t shoot because the winds would buffet the cranes and could knock them over. We lost several days because it was either too windy or not windy enough. But for the most part we had good luck with the weather.”

Although a good portion of the Mojave shots entailed planes skimming or descending into the clouds, there were several spectacular plane explosion effects on the storyboards. The first crash in the movie involved a Windsor Airlines DC-8 holding two hundred thirty passengers, which is brought down through the machinations of the terrorists. The crash, as scripted, touched off an internal debate between production principals and Twentieth Century Fox executives concerned that the sequence might alienate summertime audiences. Harlin considered several options — including a sanitized version in which the terrorists crashed a passenger-less cargo plane — but finally decided to go all-out with the original concept. “We shot what I thought was just amazing footage of the Windsor interior as the plane crashes. Before the shoot, we studied a lot of footage the FAA had photographed during crash tests, as well as data from real plane crashes. After that research, we shot the interior with passengers inside a mockup at Universal in Los Angeles. I had a camera with a very long crane arm inside the mockup — which was on a rig that had the ability of turning three hundred sixty degrees around, upside-down or sideways. I had an air blower that could be triggered to blow air on people’s faces and then I had a very bright flash effect as well. We also rigged the overhead compartments to open up so that baggage would fly out. We had the crane rush through the plane, camera rolling around, flashes on the faces and wind, stuff flying from the overhead compartments. We made several of those passes, with different shots of passengers reacting to the crash. It really looked like we were inside the airplane when it was crashing and rolling around. The only problem was it was too effective. It was originally cut in; but we all agreed it was too much, too cruel, and that the audience would have trouble settling in after that. So we cut the footage of the victims to the minimum needed to establish that there are people inside the plane.”

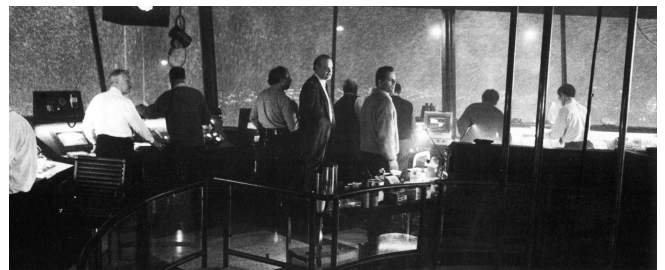
The post-crash scene of the burning wreckage — with John McClane and airport rescue crews searching hopelessly for survivors — was filmed at the Alpena location. An estimated six truckloads of scrap airplane parts were procured by Al Di Sarro and spread over a half-mile area. Local help was then hired to tear up the material using earth moving equipment. “For the shoot,” said Di Sarro, “we would set it all on fire. Then between takes we would try to put it out so that we would have something to burn for the next take. We did almost a half mile of fire trail. What we did was rig the half mile with three-quarter-inch pipe which was drilled and tapped at one-foot increments and fitted with spray heads. I pressured gasoline with air and ran it through the pipe and ignited it with some rubber cement, which gave it that chasing look.”

“The burning crash was the biggest shot for us,” said cinematographer Oliver Wood. “We did a shot on the Shotmaker — a moving vehicle — where we started at one end of the runway and drove all the way across the burning wreckage to end up on Bruce Willis. It was an enormous shot. I had a Musco light down at one end that lit the entire half-mile area. A Musco light is fifteen six-kilowatt lamps on a hundred-foot pole up in the air — it’s just gigantic. Basically it’s stadium lighting adapted to movie shooting. There was so much light coming from the fire that

we didn't need any additional lighting. We only used additional lighting when we went in close to do coverage on some of the wreckage."

The actual crash effect was executed in miniature at the Mojave location. The storyline required the Windsor pilots to make a desperate effort to pull the plane out of its collision course. The challenge for the ILM crew was not only choreographing the crash and explosion, but rigging the model so the nose would tip up in the last-ditch effort to remain airborne — no easy task considering the model's twenty-two-and-a-half-foot length and twenty-foot wingspan. "Dave Heron was the mastermind of all our rigging," said McAlister. "He had a forklift extended about forty feet into the air with a couple of cables hooked onto the forks. These cables ran diagonally down to a pair of two-foot spikes he had pounded into the ground about a hundred fifty feet from the base of the forklift. Essentially these provided a ramp down which the airplane could glide. The cables were laced through pulleys attached to the wings of the DC-8, giving lateral support, and a third cable was set up and laced through a pulley on the tail for up-and-down positioning of the nose. By adjusting the tension on all three cables, we were able to pretty much control the altitude and nose attitude of the jet as it plunged toward the camera. A fourth cable was attached to the airplane's nose and then fastened to the trailer hitch of a pickup truck idling on the runway. At the appropriate moment, the truck would scramble up to forty miles per hour, dragging the jet down the wires into camera range.

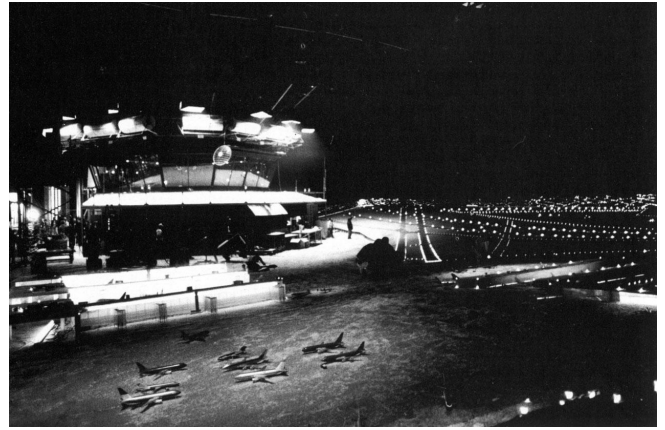
"The problem we had trying to crash the jet as planned was that the model was the same shape as a real airplane; and thus when it was dragged through the air at forty miles per hour with its nose held high, it wanted to fly, not crash. It insisted on gliding twenty or thirty feet beyond camera range. What we ended up having to do was lace the tow cable through an eyebolt secured to the exact spot where impact was to occur. This way, the jet was literally pulled right into the ground. To prevent the tow cable from snapping as it tried to drag a twenty-three-foot airplane through a three-inch eyebolt, we enlisted the help of the pyro boys. They used special explosive cable cutters to cut all the guide cables just at impact, which allowed the jet to skid down the runway after crashing."



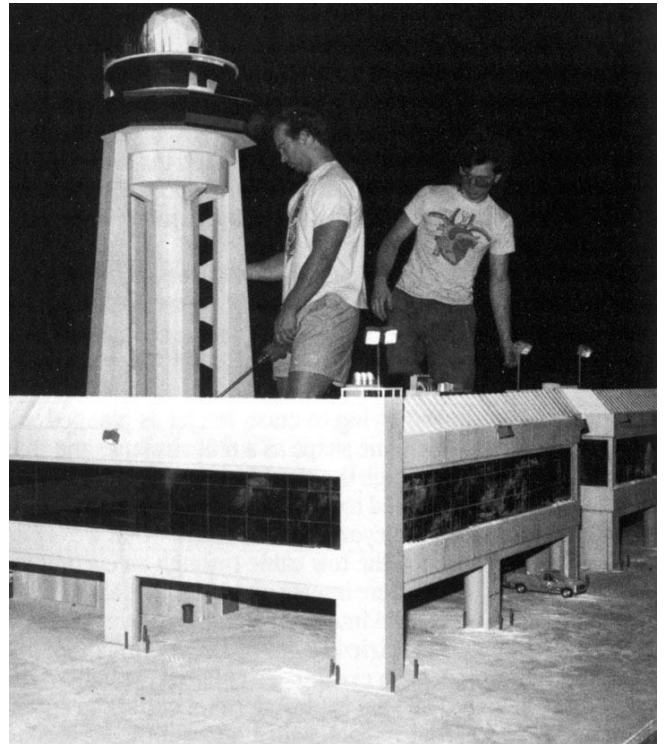
One of the principal sets of the film was the Dulles International control tower which was constructed on stage at Twentieth Century Fox.

"It was difficult to work with the wind," Bailey noted. "The planes were scale models, so they had aerodynamic lift — and a forty-mile-per-hour wind would literally just lift them off the ground. When the pyro guys had to load them up, we would put sacks of sand weighing five hundred pounds across the wings and fuselage to keep the planes from being blown away. The wind also made it difficult to paint the models since there was always dirt blowing around. After a while, we just gave up and started using the dirt to give the planes an aged effect."

The Windsor crash required three shots. The first was its hitting the runway and its nose rising upwards, the second was of the plane sliding down the runway, and the third was the whole plane exploding in a huge fireball. Instead of a single detonation, the model was rigged to break apart in a series of blasts intended to keep the audience in suspense as to the passengers' chances of survival. "Since it was shot live-action with a twenty-two-foot model packed with gunpowder and kerosene and flammable liquids being dragged behind a pickup truck at forty miles per hour, there were a lot of details to figure out," stated McAlister. "We couldn't electronically detonate the plane because forty miles per hour is pretty fast when you're trying to hit a mark. We had to be more precise than that. Inside the plane was a switch connected to a rope that was tied to a bolt in the ground. We had, say, one hundred feet of this rope coiled up so that when the plane traveled one hundred feet the rope would act like a ripcord and pull the switch that automatically triggered the explosions at the right place along the runway — one engine on fire, the other engine on fire, one wing explodes, the other wing explodes, then the fuselage explodes. It was all choreographed to extend the action, to give the audience so many chances to believe that these people were going to make it." The crash was shot



To simulate the view from the tower — which was supposed to be overlooking the flight line several hundred feet below — a forced perspective miniature was constructed on the stage floor with flashing runway lights and radio-controlled model airplanes.



For several full exteriors, Apogee was contracted to produce and photograph a miniature of the tower and the buildings surrounding it. Modelmakers John Eaves and Tom Martinek ready the foamcore and styrene mockup for a shot. Smoke and lens filters were used to create aerial density, and simulated blowing snow was matted over the entire scene.

at two hundred frames per second. Smoke in the air provided the stormy background while white gypsum sand simulated ground snow on the runway.

Once the footage was in the can, the final step was for the ILM computer graphics department to erase the wires — an especially challenging proposition given the flaying pyro-chopped cables. “We create a rotomatte for where the wires are and then take the colors from either side of that matte and smudge them across the wire,” explained computer graphics artist Douglas Smythe. “Usually we create wire removal mattes using an interactive program I wrote for *Back to the Future II*. An animator can sit down in front of a computer monitor and then bring up any frame in the sequence and plot the end points of straight line segments on key frames. In this manner we can plot the path of the wires as they’re moving across frame. That takes a day or two to figure out. Then a different computer program takes over and examines what color the pixels are in the original picture on either side of the wire and averages across between these two points, replacing the color where the wires are. But there are other things to consider — such as film grain, which to the computer looks like random noise. If you did a wire removal without taking into consideration the film grain, you’d have this stuff off in the main part of the shot that’s chattering around and doing what film grain normally does and then there’d be one little area where the wire used to be that’s very clean and unchanging and it stands out. So we have to also copy the film grain using the automatic repair method.”

In addition to the cable removal, the crash footage presented other problems to the computer graphics crew. “It was interesting from our scanning point of view,” Smythe noted, “because the footage had very bright explosions and very dark backgrounds since it was shot at night. There were some values inside the explosions that oversaturated the scanner’s sensors, making it too bright for the normal range of calibration curves our film scanners could handle. So we had to figure out ways to compensate for the brightness way up at the top without, at the same time, making the shadow areas lose all their details. We had to scan it in at several different exposures, once at the normal exposure and maybe a half stop down and a half stop up. To combine the picture where it was dark, we used the values from the hotter picture scaled to darken it to where it was supposed to be so we would still get the detail in the shadow area. And in the area where it was brighter, we used the place where we’d stopped it down and put a filter into the scanner to darken it so that it didn’t blow out the values in the scanner.”

A tense moment later in the film would provide *Die Hard 2* with its signature image. As the sequence opens, Esperanza has commandeered the C-130, and pilots the now crippled aircraft through storm clouds to a landing strip illuminated for him by Colonel Stuart. One scene of the plane on final approach was accomplished as an optical composite of the transport model over a landing strip set designed by Paul Huston using forced perspective. Once the plane touches down — again accomplished as a miniature since the real plane could not fly — McClane temporarily gets the drop on Esperanza, but is forced to take refuge inside the plane when Stuart and his troops arrive, assault weapons blazing. Al Di Sarro called on weapons specialist Mike Papick to assist with the scene. The guns fired blank ammunition at a full-scale mockup derived from molds taken off an actual C-130. The illusory impact of bullets hitting the fuselage was supplied by the physical effects crew. “We wired three thousand bullet hits on the fuselage mockup,” Di Sarro related. “The bullet hits were really painstaking to rig. Each hole had to be

drilled, loaded, tapped and wired into a sequence the director approved. The wiring for the three thousand bullet hits looked like the inside of a computer.”

After peppering the fuselage with gunfire, Stuart orders grenades to be tossed into the cockpit. In a desperate escape bid, McClane straps himself into the pilot’s ejection seat and blasts straight up toward an overhead camera view only seconds before the cabin erupts in a billowing fireball. For the explosion, a rough mockup was detonated and filmed in Indian Dunes, California. The dynamic shot required a safety-shielded, high-speed camera to be positioned on an overhead crane that looked down onto the setup. “The tricky part of that for me,” said Di Sarro, “was not only did I have to blow up the mockup, I had to get the resulting fireball to envelop the camera. We also had a wind condition to deal with. I was concerned that once I detonated this explosion the fireball might be blown from where the camera was instead of going into the camera. It was touch-and-go, but we were lucky enough to achieve the effect of the transport exploding and the fireball enveloping the camera in one take.”



Special forces commander Colonel Stuart deliberately provides false elevation readings to a British airliner, causing all on board to be killed when the aircraft crashes during an attempt to land on one of the storm-obscured Dulles runways. At the Mojave location, ILM rigged a twenty-two-and-a-half-foot model D-8 on cables and loaded it with pyrotechnics.

McClane hurtling up out of the fireball into a camera view hundreds of feet in the air was a pivotal shot for Harlin — a shot that could only be executed using effects technology. “There are some shots that are worth the money because they’re the ones that sell the movie. They’re the shots for the trailers, the shots that the audience will be talking about when they go home. I was very persistent. I wanted ILM to do it somehow.”

Mike McAlister initially had concerns that the spectacular effect would shatter the illusion of reality. “When the shot was first discussed I wasn’t too fond of it. There are certain kinds of effects shot that call attention to themselves because they defy reality — and the ejection seat is one of those shots. It’s such a bizarre point of view to be up in the air with a camera and see this guy come rolling toward you in an ejection seat that it inherently screams that it’s an effects shot. You have to execute the shot with twice the normal fidelity because everybody’s looking for the clues that tell you that it’s a fake, an optical composite. The last thing you want is for the audience to say, ‘Oh sure, give us a break!’ If that happens, they don’t want to believe anymore and it takes them out of the film.”

Another concern for ILM was that to accommodate Willis’ schedule they would have to film bluescreen plate material of the actor prior to the filming of the background explosion, making a guessing game of the lighting and placement of Willis in the final composite. The bluescreen photography involved strapping the actor into an ejection seat attached to a motorized rig that rotated head over heels. “We had a big, very safe, rotating rig built especially for this shot,” said McAlister. “Bruce was strapped in with a harness and we had him tumbling very slowly as the camera dollied in on a one-hundred-foot-long track until we were tight on his face. Later in optical, the film was skip-printed to give the ejection seat explosive speed.”

“One of the major challenges for optical was first placing the actor in the scene,” said Stuart Robertson. “We began with a very long take of Bruce Willis in the harness tumbling forward in front of the bluescreen. We had to mix elements from a lot of different formats, four-perf and eight-perf. We had to shoot it on a couple of different cameras, unload the film from a four-perf camera into the eight-perf camera to finish the shot. The foreground shot of Willis was shot in Vistavision. The unusual thing about the shot was the background explosion — which was filmed with a high-speed Photosonics camera — had not been shot yet. That makes it very



Overcoming the model’s tendency to fly was one of the major difficulties faced by the crew. The problem was solved by running the guide cables through an eyebolt secured to the runway at the designated impact point. A pickup truck towed the plane into the ground at forty miles per hour, automatically triggering the explosive charges.



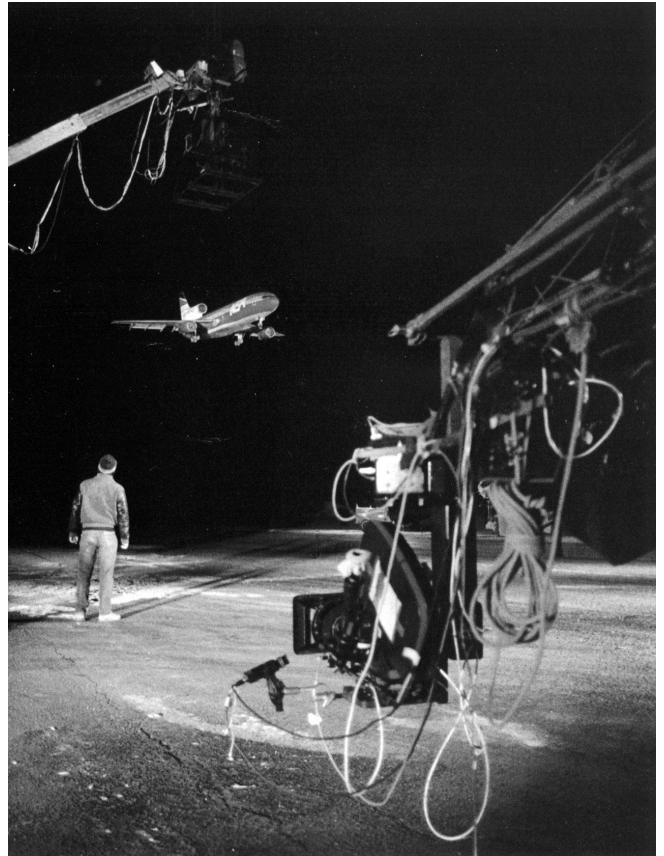
Footage of aircraft flying through storm clouds was produced by suspending the models from cranes over wind-blown clouds of vaporized mineral oil. A radio control system afforded maneuverability for the planes.

difficult because you have to guess what the background is going to be and try to tailor essentially a wild element to that. We really did it back to front. Since Mike had been forced to guess what the lighting would be on the scene, we had to add some neutral density filters to essentially manipulate the lighting after it was shot.” The composite elements of Bruce Willis in the ejection seat and the down shot of the ground-level explosion also had to be manipulated to provide realistic depth of field. “The character’s supposed to be making about a six-hundred-foot move up into the camera, but the two composite images were both shot very sharp. To make it look real, we needed to add focus pulls to the two shots; so while we were doing our composite we had to change the focus on the background explosion. As Willis came closer to the camera, we threw the background soft to give the impression that we had been moving camera focus with him. Of course, it’s a shot you would never really be able to do. But without that kind of realism, it would have looked very cut-out and unreal.”

For the final shot in the sequence, Jeff Olson constructed a quarter-scale puppet and parachute, then balled them up and tossed them off a construction crane about forty feet off the ground. Shot at high-speed, the miniature parachute opened up and floated down like the real thing.

Although the Windsor crash and the ejection seat sequence were key action scenes, the exposition necessary for building the suspense and moving the story required numerous interior sequences. One key interior was the main air traffic control tower. Although some interiors were shot at Los Angeles International Airport and Stapleton Airport in Denver, security and safety considerations made it impossible to film in an actual control tower. “It was difficult even getting permission to visit the towers for our research,” said Harlin. “When we did, it was really shocking to see how much air traffic control is dependent on humans operating machinery. The machinery in some cases is very old. We built our tower like a Star Wars kind of a tower — a hundred times more high-tech than anything we had seen for real.” The control tower set was erected on Stage 16 at Twentieth Century Fox. Outside, visible through an expanse of glass, was the airport flight line — actually a large-scale model outfitted with radio control airplanes and twinkling lights simulating Washington D.C. in the distance.

Apogee was engaged to build and photograph a miniature control tower and other airport buildings for six exterior shots. Constructed on a stage at the Van Nuys effects facility, the five-and-a-half-foot tower — fashioned from foamcore and styrene — was laid out on a tabletop surface twenty-eight feet wide and twelve feet deep. The scale buildings, which took nearly three weeks to construct, featured subtle, almost subliminal, touches such as posters the size of postage stamps and tiny ticket counters for interiors that could be seen through windows. There was also a tiny figure in the control tower mounted on a rotator, a moving truck miniature and a swaying crane. The lighting scheme was designed to duplicate a real airport at night, with flash light coming from everywhere. “There were sixty to seventy lighting units built into the set using tiny grain-of-rice bulbs as well as small quartz lamps and five-inch fluorescent fixtures built out of neon tubes,” noted effects supervisor Peter Donen. “We shot it motion control because we had the figure moving in the tower, the moving truck and swaying crane. We put as much realism into it as we could so the audience would think somebody had gone and filmed at a real airport.”



Suspended from its flying rig, the L-1011 airliner — whose imperiled passengers include McClane's wife — stands ready for an in-flight shot. In addition to supporting the subject models, cranes were similarly used to elevate both lights and cameras. Essential crew members — those controlling aircraft and camera movements — were positioned above the smoke on scissor-lifts.

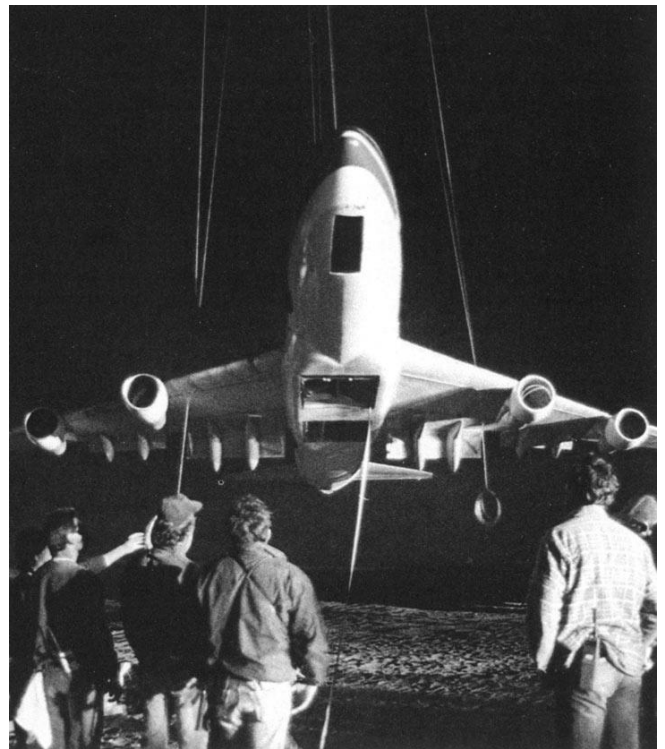
The Apogee shots also reflected painstaking efforts to match the stormy atmosphere evident throughout the rest of the movie. "We used a combination of smoke with a Harrison double-fog filter on the lens that would change depending on the focal length of the effect," said freelance effects photographer Bill Neil, who served as effects director of photography on the first *Die Hard*. "That created the atmosphere. Separate elements of blowing snow — largely composed of baking soda with a mixture of shredded feathers — were shot against black for foreground, middleground and background, and then matted over the entire scene."

Fox soundstages were also used for other important sets, including exterior views of Stuart's church headquarters for a scene in which McClane tracks the villains to their command post, and a gigantic near-scale 747 wing prop for a climactic fight scene. "I don't think this had ever been done before," said Al Di Sarro, "but I completely refrigerated Stage 15 and 16 at the studio. We needed it cold so you could see the actors' breath. That took up to twenty-eight chillers and a refrigeration unit that was brought in on a forty-foot flatbed truck. It also required more plumbing than one man could ever imagine. Since we were shooting on the entire stage, all of the refrigeration units had to be painted black so they would not be seen." Calculations indicated that unchecked condensation from the refrigeration systems would have soaked an estimated twenty thousand gallons of water into the stage walls during the course of filming. "We had to line all four walls with a plastic overlay to catch the evaporation. It was a huge job since the basic dimensions of the stage were two hundred feet long, eighty feet wide and sixty feet tall."

After McClane surprises Stuart at the church, a snowmobile chase ensues which was shot in several locales including Breckenridge, Colorado, and Lake Tahoe, California. The scene culminates



Inside the location model shop erected in a tent at the Mojave site.



A second major plane crash involved a 747 cargo carrier which the terrorists have demanded to make their escape — not counting on the tenacity of John McClane who ignites a stream of leaking jet fuel that engulfs the wing on takeoff and causes it to explode. For shots of the fire trail reaching the wing, a stationary model was

with McClane falling off his snowmobile just as it flies off a precipice and explodes above a truck passing on the road below. “What I did for the shot

suspended in a takeoff position and photographed from a speeding camera car.

was remove the engine of a snowmobile and rig a dummy replica of Bruce Willis to it,” Di Sarro said. “We laid track down across this little plateau that had about a one-hundred-fifty-foot run to the edge. We hooked a taut cable from the snowmobile over the plateau to a tree and across the road back down to a tow vehicle. One problem was that the exploding snowmobile had to fly across a real truck passing on the road below, so I couldn’t have a truck that was taller than the traverse of the snowmobile. We had to recalculate the length of track we had versus the speed with which the tow vehicle would pull it and that told us what kind of an arc we would have when the tow vehicle pulled the snowmobile off the plateau. Based on these calculations, the snowmobile would be starting its upward arc with clearance as the truck passed underneath.” The snowmobile was rigged to explode using a ripcord trigger similar to that employed by the ILM pyro crew on the Windsor plane crash. “We had a cable that was to yank the dummy off the snowmobile in midair, because we wanted to see the figure departing it just as the snowmobile exploded, so I attached another cable from the front of the dummy to a pin system switch. When the cable pulled the dummy off, the dummy pulled the cable to the switch and that detonated everything.”

In the film’s climax, the terrorists board a 747 to escape; but McClane, flying over the runway in a TV news helicopter, catches up with the jet as it is taxiing down the runway. Before the jet achieves takeoff speed, McClane leaps from the copter to the left wing of the plane and stuffs his jacket into the wing flaps preventing liftoff. As the jet continues to move down the runway in the raging snowstorm, McClane and Stuart engage in deadly hand-to-hand combat on the slippery wing.

The leap to the wing was staged by stunt coordinator Charles Picerni, who had a stuntman jump from a helicopter to the wing of a real taxiing 747. The subsequent fight was staged on an eighty-foot wing prop made of wood, painted silver and suspended twenty-two feet off the ground. The wing was attached to a section of prop fuselage which was hooked and braced to scaffolding. “That 747 wing was typical of the scale of the whole movie — huge,” Oliver Wood noted. “It was amazing to go into a Fox stage where they’ve built cathedrals and cities and find that this wing filled it up. We had to put the lights up in the rafters, one in each corner. We shot it against a black background and blew plastic snow while we filmed. The wing doesn’t move at all; but because of the editing and the wind and weather elements, it looks like it’s really moving. During the sequence, McClane falls off and we showed the runway underneath using a front projection screen.”

Before McClane falls off the wing, he manages to open the fuel tank, setting streams of fuel gushing down to the runway. He then lights the trail of fuel with a cigarette lighter. The resulting fire trail chases after the 747, engulfs the left engine just as the plane leaves the ground and blows up the jet. “It was a great concept,” McAlister observed, “but the fire trail blowing up the plane could never happen in reality. The thrust from the engines at takeoff speed would blow out the fire. Besides, when you light a trail of jet fuel the fire barely creeps forward — it doesn’t just go ‘whoosh’ as it does in the movie.”

To realize the effect, the production first filmed a real 747 taxiing down a runway in Alpena, Michigan. The plane — and a much welcomed snowy night and runway — provided the background plate for a fire trail composite. There were two phases to the fire trail effect — the chasing flame itself and the fire element that shoots up from the runway to engulf the engine and wing. “We shot the fire trail at ILM,” said McAlister. “We laid a long pipe on the ground, blew lots of propane gas through it and then lit it at one end. After the flames were shot, they were made into registered workprints for rephotography on the pinblock by Pat Myers of the effects camera department. The entire fire trail was a ‘cut and paste’ element consisting of flames from eight different fire elements. Each piece was photographed on the effects camera with a program matched to the 747 plate and scaled to the correct size. As the flames were composited to the background plate, we also had to add reflections of the fire trail on the snow. The reflections were necessary because fire is a light source which illuminates whatever is nearby. Without the reflected firelight, the flames would have looked pasted onto the scene.” For the cut of the leaping flame catching the wing, Pat Myers rephotographed footage of a flamethrower firing up into the air, resizing and repositioning it on the pinblock so that it would strike the engine at the right spot and moment.

Model work for the shot — accomplished at the Mojave location — involved suspending the huge 747 model twenty feet above the ground from a sixty-foot crane. Four cables were secured through the model’s support bar — one for each wing and two for the nose and tail. The plane had to be rigged in two positions — one for an up-shot of the craft suspended in an ascending mode with the fire trail catching the wing and the other for the subsequent detonation of the model. For the shot of flames engulfing the wing, the model was suspended in the liftoff position. An interchangeable fireproof engine attached to the wing was set on fire as the camera crew made a pass from a camera car moving at forty miles per hour. The camera itself was rolling at more than two hundred frames per second.

The final explosion was designed prior to the location shoot, with McAlister and pyro expert John McLeod testing various pyrotechnic materials to determine the proper sequence and desired look of the detonation. “The 747 was designed to explode in three blasts,” recalled McAlister, “with a certain amount of delay between each one. We ended up primarily using a combination of gunpowder and kerosene and primer cord.



The 747 explosion was produced by loading several hundred pounds of pyrotechnic materials into a twenty-three-foot model which was then lifted fifteen feet in the air. Four highspeed cameras were positioned to record the sequential blast which was triggered electronically.



The burning wreckage provides adequate illumination for the planes that have been helplessly circling the airport to land safely. For his final shot in the film, Renny Harlin wanted to begin in close on the reunited McClares and then pull back to a wide vista that revealed all of the planes, plus dozens of vehicles and throngs of passengers and airport personnel. The only way to

Gunpowder would be used for the really big explosion, the primer cord would tear the airplane apart and then the kerosene would give a long-lasting, billowing type of fireball with pieces tumbling off and continuing to burn, as opposed to everything just exploding and dying out right away.”

achieve the shot economically was with a matte painting.

It took McLeod and his crew a full day to load and wire the explosives so that the plane could be detonated electronically in a sequence of blasts a few hundredths of a second apart. “The pyro guys put somewhere between three and four hundred pounds of explosives into the plane,” noted Charlie Bailey. “At the time, only they really knew just how big the explosion was going to be.” By nightfall, the loaded-and-ready model was wheeled out on a dolly and rigged to the construction crane. As lights and four cameras were positioned, the model was hooked to the crane wires and lifted fifteen feet into the air. A wire to detonate the model ran from the nose to a bunker fifty yards off-camera. “Once we had the plane suspended in the air and all the cameras and lights were ready, everybody cleared out of the vicinity,” McAlister recalled. “We rolled our cameras and Johnny McLeod, who was in his little bunker, touched the wire to a battery and — BAM!”

“When it went off,” Bailey related, “it created a mushroom cloud like a miniature nuclear explosion. First there was a fireball about a hundred feet in diameter and then a mushroom cloud that must have been a couple hundred feet in the air. For several hours after the explosion, the airport was getting calls from people who wanted to know what plane had crashed. The explosion was so big that people could see it from the freeway miles away. Afterwards we went over the site to find usable parts for the final debris shot, but there was nothing left — just bits and scraps.”

In the movie, the fire trail and the flaming wreckage of the 747 provides the illumination necessary for Holly’s L-1011 and the rest of the circling planes to land safely. “In Alpena,” noted Harlin, “we shot a real L-1011 landing. I think it was the most amazing shot in the whole movie. It was a very foggy night and we had the runway lights turned off and a three-foot-high fire trail on the runway. The plane came out of nowhere through the fog and snow and smoke, and landed — guided by the light of the fire trail. We then shot the scene where the passengers get out, but we needed an in-between shot of Holly’s plane skidding to a stop in the deep snow. I was planning to shoot it wide angle with the real plane, then use inserts with the wheels braking; but there wasn’t enough snow on the runway for the look we needed. That’s one of the advantages of doing a big movie. I could go to the studio and say I needed those shots because we had to show the dramatic situation of how dangerous it was to land on such a snowy runway.”

Harlin had Paul Huston storyboard the sequence, the studio came up with the extra money for the effect and the ILM model unit prepared the shot in the Mojave. Huston also provided information as to the foggy conditions, allowing the Crash and Burn crew to match the atmospheric look of the live-action with smoke. “We had about a half acre of the runway covered with gypsum sand,” Bailey reported, “which looked just like snow. The riggers then laid down a plywood track beneath the snow and a cable was attached to the back of a truck and the nose of the plane. The plane was rigged with skids under the wheels so that snow would be

kicked up as it was dragged along the rough surface of the runway. The truck propelled the plane and the skids slid along the plywood track to give the plane the curved trajectory required. The shot was filmed at about two hundred frames per second to give the jet and the kicking snow the mass of full scale. These shots were given to us at the last minute; and while it was a risky approach, it worked perfectly.”

The final scene is a pullback shot that starts tight on a happily reunited John and Holly McClane and moves back to reveal the snowy runway crowded with six jumbo jets, police and emergency vehicles, and dozens of passengers and emergency crew members. Setting the shot up live-action using real planes and equipment was virtually out of the question. The cost of renting the planes alone would have been astronomical; lighting a scene of such scale would have been nearly impossible; and, of course, there was the continuing snow scarcity problem. But Renny Harlin — always interested in the spectacular camera angle — wanted to realize the shot. “Renny wanted something similar to a shot he had designed for his *Nightmare on Elm Street* movie,” Paul Huston noted. “In that film, one of the characters dreams he’s in Freddy Krueger’s nightmare world. The camera starts out on him in this junkyard where he’s surrounded by junked cars that come to life and trap him. The camera then pulls straight up from him to reveal the whole of this junkyard world. Renny wanted something similar for *Die Hard 2*, with John and Holly McClane riding away in a golf cart as the camera pulls back above the planes.”



The closing matte shot was fraught with difficulties. Not only was it thirty-five seconds long — well beyond the optimum for a painting — but it had to incorporate six live-action plates and an array of effects such as flashing lights and haze. After carefully working out the composition and perspective, matte artist Yusei Uesugi spent five weeks on a painting that was thirteen feet wide and five feet tall — four times the size of a typical matte painting.

An elaborate matte painting was devised to achieve the shot. Even so, problems and obstacles were manifold. First, the shot was thirty-five seconds long — much longer than the three to five seconds considered optimal for a matte painting — thus giving the audience ample time to scrutinize the shot. Also, the shot would have to blend six live-action plates of people and vehicles on the crowded runway and incorporate additional elements such as blinking lights, steam and haze needed for movement and realism. “The scale of the shot presented too many problems to overcome using conventional matte painting techniques,” stated matte department supervisor Bruce Walters. “To scale the painting proportionately, Yusei Uesugi — our matte painter — would have had to make the painting thirty feet

long and fourteen feet high. Our matte painting room is only twenty-four feet wide, so that would not have even physically fit into our space. Then to light something that big would have required a room forty to fifty feet wide. Plus, the projection elements would not have looked very good because we would have been doing quite a large zoom, and rear projection elements tend to look best when you’re looking straight at them from the same axis as the projector. We would have been quite off-axis as we zoomed back, so lining them up properly would have been difficult and there would have been a parallax shift. One night I came up with the idea that maybe we could do the shot as a digital painting. Using digital techniques to seamlessly blend painting and live-action plates together had never been done to such an extent in film before.”

Uesugi and Paul Huston developed the final design — vital for determining not only the matte painting, but the composition for the live-action plates ILM would later shoot — by setting up small model airplanes on a board. “Yusei set a still camera at just the right angle,” said Walters, “and then moved everything around, got the shadows to work right by using nails in the board to simulate people, and determined all the perspective lines and things he would need for the painting. What he ended up with was a still frame of film that was basically the matte painting. Then we projected that down in a rotoSCOPE camera and traced out the lines so we would have a drawing of that picture that everybody could use in a grid to align their cameras. Yusei loaded that onto the Automatte camera we use to shoot matte paintings, projected it out onto a painting surface and marked in where we wanted people to be. Paul Huston and Mike McAlister figured out the composition where the people should be for the live-action so it would all fit in with the painting.”

As a painting guide, prints of each of the six different plates were pasted onto the surface of the painting area in their approximate positions. Uesugi’s painting — which took five weeks to complete, measured approximately thirteen feet wide and five feet tall — still four times the size of a typical matte painting, but the minimum size necessary for a quality look. “Even though the



The painting was then photographed and scanned into a Macintosh II computer along with the live-action plates and the ancillary effects. Working with the computer graphics department, Uesugi was able to blend all the elements together digitally and then have the final product output to film with the pullback move included.

painting was so big,” said Uesugi, “the center of the pullback effect — where the shot starts — was only a foot wide, so I had to put a lot of detail into the center of the picture. I painted it rougher, with less detail, as the painting moved out to the edges.”

To digitize the entire painting at a high resolution would have required too much computer memory. Using the matte painting concept of less resolution toward the outer edges — an effect which still creates the illusion of reality when viewed at a distance — four photographs of progressively wider compositions were made of the painting which could be scanned into a Macintosh II by the computer graphics department and fitted together like pieces of a jigsaw puzzle. Like a bull’s-eye with four circles radiating outward, the digitized shot had the highest resolution at the center and less resolution as the camera pulled back. “With the computer,” stated Walters, “we were able to create a thirty-five-second move with only four frames of information in the picture. If we had done it with a camera, we would have needed more than eight hundred forty frames of information. Since we were starting in close on the painting, we began by shooting it at high resolution; and then, as we moved back to twice the distance away, we used a half-resolution. Further and further back it needs less resolution, but the image quality stays the same because you’re pulling away from the image.

“On one of our effects cameras, Pat Myers programmed the overall pullback move, all the plates, all the elements such as steam and blinking lights, and the four views of the painting. The center live-action plate had a zoom lens move on it that needed to match with the pullback on the painting, so Pat created that in one of our effects cameras in advance to make sure we had it all working. The night plates were all shot on 5296 — not a very good projection stock for process work, but digitally we could scan in the interpositive from the negative and keep the quality at an acceptable level. Computer graphics could take it and blend everything together using that information.”

Once the images were scanned into the computer, Uesugi could view the image on a monitor and work the colors and blends using ‘Photoshop,’ a revolutionary Adobe Company software designed in part by ILM team member John Knoll. Instead of the customary matte work woes — such as having to repaint or redesign images — Uesugi could experiment interactively with colors and blends using an electronic pen on a digital tablet instead of paint and brush.

“At thirty-five seconds, it was the longest continuous shot the current computer graphics department has ever dealt with,” observed Doug Smythe, “but it also looks good because you’re close to seeing the original painting, without generation loss due to new film grains and film distortion. To do that required an amazing amount of computer information. A normal Macintosh disc has about one megabyte of information, while the discs we use on our main computers hold about six hundred megabytes of information. For the shoot, we used about fourteen or fifteen of those discs. So if you took all of the information that we used in the shot, starting from the original pictures of the matte paintings and then all of the insert elements, plus all of the intermediate steps that we went through to process those elements and then the pictures that were actually scanned out to film — which weren’t always on disc at the same time, we’d have to shuffle them back onto magnetic tape — what we did probably would have required on the order of ten thousand normal Macintosh discs.”

Despite taxing the computer memory banks, the shot was considered a successful expedition into the technological frontier. “Personally,” Walters stated, “I think this is the biggest movement in special effects since motion control. There are so many things you can do digitally that you cannot do any other way. Once something is scanned into the computer, the quality doesn’t break down and as many people as you want can work on it in parallel. And instead of an artist having to wait a day or more for a test composite, there’s no waiting for anything — it’s all interactive. The artist instantly sees how everything is blending together. It’s really satisfying to have so much power over an image.”

In the grand spare-no-expense Hollywood tradition, the stunning visuals of Die Hard 2 came at a cost — various nonstudio sources have placed its overall pricetag at an all-time record \$70 million. But with more than \$100 million domestic gross alone and reports of record boxoffice in the global marketplace, Die Hard 2 was one of the biggest films of 1990. “I was used to doing low-budget movies,” Renny Harlin reflected, “so coming into Die Hard 2 I’d sometimes get worried about cost. Joel Silver would tell me, ‘Nobody’s going to come to you after the movie comes out and say, “Thank God you saved that dollar.” Everybody’s going to look at what’s on the screen and judge you and the movie based on that.’ This kind of movie is like a giant training program because you get to try everything and use every existing technique. With the effects technology that now exists and the right people to work with to express your ideas, almost anything is possible.”

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